OFF-PEAK CONTROL OF WATER HEATERS ON RURAL POWER SYSTEMS

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Off-Peak Control Of Water Heaters On Rural Power Systems

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OFF-PEAK CONTROL OF WATER HEATERS ON RURAL POWER SYSTEMS

INTRODUCTION

AS a result of power shortages, high demand charges, and increasing loads, REA-financed cooperatives are showing wide-spread interest in means of reducing peak demands on their systems.

The control of domestic appliances to remove them from distribution systems during peak load periods has been considered by the electrical industry for many years. Investigations have shown that the only types of appliances to which off-peak control is applicable are those that act as storage units. Water heaters and some types of water supply systems come under this classification. The conditions of use of modern refrigerators and home freezers are such that they must be excluded from the general classification of controllable appliances. Water systems of the pressure type cannot be controlled as they have little reserve and must operate whenever the pressure falls because of water demand. Water pumps associated with storage tanks in gravity pressure systems can be kept off during peak load periods, provided that the storage capacity is sufficient and that the control device can be bypassed in cases of emergency. The storage type water heater is, therefore, the principal appliance that lends itself to off-peak control without serious use limitations.

The storage type water heater is designed to supply instantaneously a quantity of hot water that has been heated at a slow rate over a period of time. As most heaters are designed to heat the total capacity of the storage tank in less than twelve hours, shutting off energy to the heating units for short periods of time will have little effect on the amount of hot water available.

Many rural power system engineers have felt that off-peak control of water heaters offers a logical approach to the problem of reducing peak loads on their systems. However, any accurate estimation of the value of water heater control has been made very difficult because of the lack of information about water heater loads on rural systems.

Investigation of the characteristics of water heater loads has included two tests made on REA-financed distribution systems. The first test was performed in October and November 1947, on the lines of the Oakdale Cooperative Electrical Association, Oakdale, Wisconsin. The second test was conducted in November and December 1947, at the Steuben County Rural Electric Membership Corporation, Angola, Ind.

These tests were made by the Technical Standards Division of the Rural Electrification Administration with the cooperation of Lloyd McCaskey, manager, Oakdale Cooperative Electrical Association; Charles L. Puffer, manager, Steuben County Rural Electric Membership Corp.; members of the two cooperatives; Charles E. Seymour, consulting engineer, Baraboo, Wis.; the Control Corp., 718 Central Ave., Minneapolis, Minn.; and the Line Material Co., Wired Radio Division, East Stroudsburg, Pa.

OBJECT OF TESTS

Information was sought on the characteristics of water heater loads and their relation to the rural system load. The following specific topics were investigated:

1. The characteristics of the load added to the power system by water heaters that are not controlled.
2. The characteristics of the load added to the power system by water heaters after they have been held off for several hours during the system peak load period.
3. The most satisfactory combinations of tank and element sizes for water heating in rural homes.
4. The amount of energy used per month by water heaters and factors which affect this use.

SCOPE

The information presented in this report is based on conditions observed during one season of the year on two rural power distribution systems. These two systems were chosen because the centralized water heater control equipment installed on them made it possible to obtain considerable information in a short time with the limited personnel and equipment available.

CONCLUSIONS

Water heaters contributed between 500 and 600 watts per heater to the peak demands on the two systems tested. The measured contribution per heater was 520 watts on the Oakdale system and 600 watts on the Steuben system. Water heaters on the Steuben system averaged larger in tank size and considerably larger in lower element rating than those on the Oakdale system. This difference in heater characteristics did not appear to influence the average measured load per heater during peak load periods. The load per heater seems to be more closely related to the kilowatt-hours used in heating

water than to either the element or the tank size.

The size of heating elements is important in limiting the amount of water heater load that has to be "picked-up" after water heaters have been kept off for several hours. After 3 hours off, the measured water heater load exceeded 75 percent of the connected water heater load. However, 2 hours after re-energizing, the water heater load had returned to normal.

Water heaters should have adequate storage capacity to take care of washday and bath activities. Where this requirement was met, users were unaware that heaters were cut off for a 3-hour period during the evening peak.

Water heaters of 50 gallons capacity or larger appear to be desirable for farm family use. Smaller heaters are too often inadequate after users become accustomed to having hot water available. The amount of hot water used appears to be affected more by living habits and farming methods than by such factors as family size or the size of the farm business.

Heater element sizes should be a function of tank size. A two-element heater with approximately 20 watts per gallon of tank capacity for the lower element and 30 watts per gallon for the upper element appears to be the most satisfactory combination. The two thermostats should be interconnected to limit the maximum demand of any water heater to the rating of the upper element. This combination of element ratings and interconnected thermostats provides a good compromise between heater demand and recovery rate.

The two centralized control systems observed during the test periods did not operate satisfactorily. Constant maintenance and supervision of the equipment were necessary. The manufacturers of the equipment are aware of the deficiencies and are taking steps to correct them.

A careful analysis of each system should be made to determine the economic feasibility of the application of water heater control equipment. Appendix I, Economic Considerations in the Application of Water Heater Control Equipment, has been prepared to assist those interested in considering the use of centralized water heater control equipment.

DESCRIPTION OF TESTS

Each of the two distribution systems on which these tests were made in general served family-sized farms. Each system received power at only one location. At the time of testing, each served approximately 100 water heaters.

The Oakdale Cooperative Electrical Association serves consumers principally engaged in dairying and diversified farming. On these farms, which are typical of most dairy farms in Wisconsin, the business includes dairying, crop farming, poultry, hogs, some sheep, and some beef cattle. The predominance of dairying is indicated by the saturation of milking machines, estimated at 90 percent.

The Oakdale tests were made in September and October 1947. Electric water heaters were being used by 107, or 4.4 percent, of the 2,387 consumers. All of these heaters were controlled by a carrier current transmitter located at the 1500 kilovolt-ampere substation. Central metering equipment for the test was installed at this location.

The Steuben County Rural Electric Membership Corp. also serves a diversified farming area. The emphasis is on livestock and crop farming. Dairying is not as predominant as in the Oakdale area.

The Steuben tests were made during November and December 1947. The Steuben system served 1,692 consumers at the time of testing with 96, or 6.5 percent, of these having water heaters under centralized control. A few additional heaters not subject to control were in use. Power was received through one metering point. Additional metering equipment was installed a few spans beyond the permanent metering point, for load measurement during the test period.

The general procedure used in making measurements was approximately the same for both systems tested. Recording wattmeters were installed at the supply point to obtain a continuous record of the system load.

All information obtained on total system load and water heater load was taken from the records provided by these meters. The total system load was shown directly by the wattmeter records. The water heater load was measured by switching off all water heaters for 1 minute each hour by means of the centralized control system. This caused the wattmeters to record the change in the total load, equal to the water heater load at that time. This is illustrated by the sample charts shown in figures 1 and 2 of appendix II and figures 1 and 2 of appendix III.

Hourly readings of water heater load were taken throughout the test period. An automatic timer was connected to the carrier current transmitter to cause it to send signals that would make the water heater control receivers go through the "off-on" sequence of operations at 1-hour intervals.

Measurements at intervals of less than 1 hour would have provided additional information. However, the total number had to be kept to a minimum because all heaters were being kept off for 1 minute each time a measurement was made. Too frequent measurements would result in enough "off" time to upset the normal thermostatic cycling of the individual water heaters. Some additional measurements were made during important periods of the day, especially during maximum load periods.

Records for each system were made for 2 weeks with the heaters operating normally, except for the hourly measurements. Similar tests were made with the heaters cut off during evening peak load periods. This information is presented in the form of tabulations. These may be found as table I of appendix II and table II of appendix III. The data for the full 24-hour records have not been presented in tabular form. The useable days of record have been redrawn to appropriate scale and are presented as curves, figures 3 through 16 of appendix II and figures 3 through 20 of appendix III.

Recording voltmeters were used to provide a record of all water heater switching operations. At Oakdale, the voltmeter gave an indication of carrier signal strength, in addition to the time record of each operation. At Steuben, the voltmeter operated from a standard water heater control receiver to record the switching operations. Samples of these records are shown as figure 17 of appendix II and figure 21 of appendix III.

Individual records were made on as many water heaters as time and facilities would permit. This was done to supplement the information obtained by metering the system load. An attempt was made to select heaters of representative tank sizes and element ratings. Recording ammeters were used to obtain continuous operating records of each element in 2-element heaters. Recording voltmeters were used to obtain records on single-element heaters. Sixteen individual heater records were made at Oakdale and 18 were made at Steuben. Figures 18 and 19 of appendix II and figure 22 in appendix III illustrate the type of record obtained at these locations. A summary of the data obtained from these records is given in table IV of appendix II and table III of appendix III.

TABLE I

TEST RESULTS

	OAKDALE	STEUBEN
A. GENERAL DATA		
1. Dates of test periods	Sept.–Oct. 1947	Nov.–Dec. 1947
2. Miles of line	909	363
3. Consumers connected	2,387	1,693
4. Total energy sold, average kilowatt-hours per month per consumer	117	152
5. Monthly peak demand, kilowatts	1,145	1,008
B. SYSTEM WATER HEATER DATA		
1. Consumers with water heaters:		
a. Number	106	110
b. Percent	4.4	6.5
2. Water heater sizes:		
a. Number of 30 gallon heaters	40	6
b. Number of 40 gallon heaters	10	17
c. Number of 50 gallon heaters	51	44
d. Number of 60 gallon heaters	1	16
e. Number of 80 gallon heaters	4	27
f. Average tank size, gallons	43	57
3. Average connected load, lower elements, watts per heater	1,070	1,970
4. Average measured load during peak, watts per heater	520	600
5. Average load picked up after 3 hours off, watts per heater	1,030	1,650
6. Average energy used for water heating, kilowatt-hours per month per heater	200	220
C. WATER HEATER SAMPLING DATA, WHERE INDIVIDUAL RECORDS WERE MADE		
1. Number of individual records made	16	18
2. Average length of records, days	26.6	17.9
3. Average energy used for all purposes, kilowatt-hours per month per consumer	588	532
4. Average energy used for water heating, kilowatt-hours per month per consumer	245	296
5. Average water heater tank size, gallons	46	55
6. Average connected load, lower elements, watts per heater	1,175	2,000

DISCUSSION OF TEST RESULTS

The information provided by these tests represents conditions during only one season of the year. It should be recognized that seasonal variations in the use of hot water may affect the influence of water heaters on system loads.

The data shown as Items A–2, A–3, A–4, and A–5 are taken from records of the distribution systems. These figures show the status of the Oakdale and Steuben systems as of September 30, 1947, and November 30, 1947, respectively.

The number of water heaters shown under B–1 of the tabulation is the number connected at the time tests were completed. In calculating the test results shown as Items B–4, B–5, and B–6, adjustments were necessary because few of these heaters were installed while the tests were in progress. Additional corrections were required because some control receivers failed to operate at various times during the tests. It was necessary to assume that the control system at Oakdale was only 85 percent effective and the one at Steuben 90 percent effective. This was done to minimize possible errors in test results due to failures of the control equipment. These figures are based on the following observations:

Oakdale Tests: A preliminary check at Oakdale revealed that almost half of the control receivers were not functioning properly. They were adjusted or replaced at that time so that all of them were operating correctly. A second check made 40 days later, after completion of the tests, showed that 12 percent of the receivers were again not operating properly. Test records from 16 individual water heaters showed that most of the receivers failed to operate consistently. The inconsistent operation was apparently due to variations in signal strength, inadequate voltage compensation, response to line surges and power interruptions.

Steuben Tests: Records from 18 individual water heaters showed numerous cases of false receiver operations. These were attributed to spurious signals originating in appliances such as vacuum cleaners, electric drills, and food mixers. These signals often left control receivers in the "on" position when they should have been "off," or vice versa. Hourly transmitter signals sent by action of the special automatic timer installed for testing caused all receivers to operate twice without correcting any that were reversed. The reversed receivers were corrected four times per day by manual operations of the transmitter. Under normal operation, the receivers are automatically corrected by any transmitter signal.

The equipment faults found during these tests are known to the manufacturers concerned, and steps are being taken to correct them.

A greater saturation of water heaters would have been desirable for these tests. Accurate measurement of the water heater load during light load periods was sometimes rather difficult because the water heater load was so small. Fortunately, this was not true during system peak load periods and during other periods when most of the energy for water heating was used. However, experience from these tests indicates that a water heater saturation of approximately 5 percent represents the lower limit at which accurate water heater load information may be obtained from system measurements without undue difficulty.

The connected water heater load, Item B–3, includes only the lower heating elements of all water heaters. The records from individual heaters show that the upper elements are used very little, even on heavily loaded heaters. In the Oakdale tests the upper elements accounted for less than 2 percent of the energy used by two element heaters. In view of this, little consideration should be given to upper elements when calculations are made of water heater loading. The tests support the opinion of manufacturers of two-element heaters that the upper element is an emergency booster unit.

The average measured load during peak, Item B–4, is the watts per heater contribution to the monthly measured peak that may be expected from the water heaters as a group. It is the reduction in peak demand that could be accomplished by keeping the water heaters off during the peak load periods. This figure is based on measurements of approximately 100 heaters and does not apply where only one or a few heaters are involved.

The average energy used per month by all water heaters, Item B–6, was calculated from the hourly readings of system water heater load.

Part C of the tabulated data refers to sampled water heaters on which recording meters were used. Additional information on these heaters is given in appendix II, tables V and VI, and appendix III, table IV.

Items C–3, C–4, C–5, and C–6 give information on the sampled heaters. These correspond to the information on all heaters shown as items A–4, B–6, B–2f, and B–3 respectively. The energy used for water heating in the sampled heaters (C–4) was calculated from the heating time, assuming that each element operated at rated input.

APPENDIX I

Economic Considerations In The Application Of Water Heater Control Equipment

RESULTS of the two tests conducted on REA-financed cooperatives indicate that some systems may apply water heater control to considerable advantage. Where conditions of load characteristics, water heater density, and wholesale power demand costs appear favorable to the use of water heater control equipment, consideration should be given to a study of its application.

The chart, figure 1 (facing page 7) has been prepared to assist those interested in making a cost analysis of water heater control application. This chart is based on an average water heater contribution of 600 watts per heater during the system peak. Test data in this report indicate 600 watts is a reasonable amount to expect. This chart has two values for total installed cost per controlled water heater for each demand charge and each estimated annual maintenance cost. These values are based on two rates of amortization: A 5-year rate of $17.50 per month per $1,000 invested; and a 10-year rate of $10 per month per $1,000 invested.

Very little information is available to indicate the annual maintenance costs to apply to the types of water heater control equipment now in production. All equipment must have regular inspections to ascertain that it is operating properly. Until more information is available, a maintenance cost based on at least one inspection each year should be used. The actual cost of inspections will be determined by local conditions. This cost should cover transportation, labor, and repairs for each control receiver and for the transmitter facilities.

The recommended allowable investment as determined from the chart does not take into consideration possible savings effected by released distribution, transmission and generation capacity; deferred heavying up of the system; or improved voltage regulation. All these items have considerable value to the system operators. However, the characteristics of water heater control are such that each kilowatt released by means of the control is not equal in value to a kilowatt of capacity made available by additional distribution or generation facilities. The main reason for this inequality is that additional generation and distribution facilities make capacity available in such a manner as to increase the firm, or dependable, capacity of the system. Water heater control releases additional capacity by removing a certain portion of the load from the system during the peak load period. In general, such an installation of water heater control would have only one set of facilities per substation load area and under these conditions could not fulfill the requirements of firm capacity. The capacity released by control of water heaters can be compared to that supplied by a generating plant having only one generator. Such a plant has no firm capacity as there is no alternative machine to replace the regular machine if it has to be out of service for repairs.

The actual long-term savings that can be made by releasing capacity are extremely difficult to evaluate and are likely to be over estimated. However, as previously stated, such savings are real and of considerable value to the operating cooperative. In view of the present meager information on the reliability and life of control equipment, and with the knowledge that each distribution system will have its own unique conditions of load distribution and density, line costs, and service costs, it is recommended that the economic justification of water heater control equipment be determined on the basis of power bill savings alone. If the equipment can be justified by applying the full value of the reduction in wholesale power costs to the water heater control equipment and its operation, the savings realized from the other factors such as released capacity, improved regulation, and deferred "heavying up" can be considered the gains on the capital investment in the equipment. In other words, it is recommended that total power bill savings be applied to the cost of water heater control equipment and its operation. Other savings as outlined above will then be considered as the return on the equipment investment. This will allow the cooperatives to serve controlled water heaters at rates that are attractive to the consumers and still keep the cost of such service not greater than the returns on the off-peak energy sales.

Following is an example of a distribution system water heater control problem:

Problem: A rural distribution system has a total of 500 water heaters to which control equipment is believed to be applicable. The wholesale power rate is such that a reduction of one kilowatt in the monthly billing demand will reduce the power bill by $1.75. It is estimated that on a maintenance program where all water heaters are checked annually the transportation and labor costs would be about $2.50 per heater, not including repairs to the receivers or transmitter. The manufacturers of the proposed equipment estimated that annual repairs to all the equipment should not exceed an average of 50 cents per heater. The total estimated yearly maintenance per heater thus becomes $3.

Manufacturers have submitted prices for control systems not including accessories. Current transformers, potential transformers, lightning arresters,

fused cutouts, buildings, meter sockets, wire and other materials, and the cost of installation are not covered in the equipment prices quoted.

The management of the distribution system would like to know how much money can be profitably invested in water heater control equipment.

Solution of Problem: The $1.75 per kilowatt reduction in monthly billing demand is applied to the curves of figure 1. This is represented by the dotted line A–A1. Where this line intersects the "No Maintenance" line, the dotted line B–B1, is drawn. This reveals that with no maintenance a total of $105 could be invested for each heater on a 10-year amortization basis, or $60 could be invested on a 5-year basis.

The estimate of $3 annual maintenance per heater is applied to the curve. At the intersection of the "$3 Maintenance Per Year" line with the dotted line A–A1, dotted line C–C1 is drawn. This shows that with the $3 annual maintenance per heater, the allowable investment per heater has dropped to $80 for 10-year amortization and $45.80 for 5-year amortization.[1] These figures do not include any margin of profit on the investment. The allowable investment represents the amount of principal and interest that would be repaid by the reduction in wholesale power costs over the period of amortization. This repayment is correspondingly reduced by the amount that has to be diverted for maintenance.

To obtain the allowable investment for the complete water heater control system, the $45.80 per heater from figure 1 is multiplied by 500, the number of heaters. This gives a maximum allowable investment of $22,900 for this installation.

The next step is to determine the total installed cost of the proposed water heater control system. Local conditions, the type of control equipment contemplated, etc., will cause wide variations in the cost of the completed system. Anyone interested in the total cost of such an installation can determine this by filling in the appropriate blanks in the following work sheet entitled "Cost Breakdown of Water Heater Control System." This sheet has been compiled to cover items for any type of water heater control equipment.

[1] In view of the meager information on maintenance costs it is suggested that all preliminary calculations on water heater control be based on the 5-year amortization. This will allow a cushion for additional maintenance and permits more rapid replacement of equipment due to deterioration and obsolescence.

TOTAL ALLOWABLE INVESTMENT PER HEATER FOR WATER HEATER CONTROL

$10. $20. $30. $40. $50. $60. $70.

TOTAL DOLLAR SAVINGS FOR EACH KILOWATT REDUCTION IN DEMAND

2.00 1.90 1.80 1.70 1.60 1.50 1.40 1.30 1.20 1.10 1.00 .90 .80 .70 .60 .50

A — $12.00 PER YEAR MAINTENANCE

$11.00 PER YEAR MAINTENANCE

$10.00 PER YEAR MAINTENANCE

$9.00 PER YEAR MAINTENANCE

$8.00 PER YEAR MAINTENANCE

$7.00 PER YEAR MAINTENANCE

$6.00 PER YEAR MAINTENANCE

$5.00 PER YEAR MAINTENANCE

$4.00 PER YEAR MAINTENANCE

$3.00 PER YEAR MAINTENANCE

$2.00 PER YEAR MAINTENANCE

$1.00 PER YEAR MAINTENANCE

NO MAINTENANCE

A1 — B — C — C1 — B1

$10. $20. $30. $40. $50. $60. $70.

AMORTIZATION OF INVESTMENT ON BASIS OF 5 YEARS

$10. $20. $30. $40. $50. $60. $70. $80. $90. $100. $110. $120. $130.

AMORTIZATION OF INVESTMENT ON BASIS OF 10 YEARS

FIGURE 1

ALLOWABLE INVESTMENT PER WATER HEATER BASED ON CONTRIBUTION OF 600 WATTS PER HEATER.

COST BREAKDOWN OF WATER HEATER CONTROL SYSTEM

Basic Control Equipment Cost

1. Transmitters	$_____	
2. Receivers	_____	
3. Coupling units	_____	
4. Freight	_____	
	_____	
Total cost of basic equipment	$_____	$_____

Accessories to Basic Equipment

1. Potential transformers	$_____	
2. Current transformers	_____	
3. Distribution transformers to power transmitter equipment	_____	
4. Termination units (if needed)	_____	
5. By-pass units (if needed)	_____	
6. Meter sockets (if needed)	_____	
7. Lightning arresters	_____	
8. Fused cutouts	_____	
9. Blocking chokes for power factor correction capacitors on system	_____	
10. Blocking chokes for supply isolation	_____	
11. Spare parts for inventory	_____	
12. Miscellaneous hardware	_____	
13. Miscellaneous wire and cables	_____	
14. Load recording instrument	_____	
15. Meter test switch and cover	_____	
16. Test equipment	_____	
	_____	
Total cost of accessories	$_____	$_____

Miscellaneous

1. Buildings to house transmitter	$_____	
2. Property necessary for buildings	_____	
3. Special control circuits	_____	
4. Overhead	_____	
5. Taxes	_____	
	_____	
Total cost of miscellaneous equipment	$_____	$_____

Labor Costs

1. Installation of transmitter equipment	$_____	
2. Installation of receivers	_____	
3. Installation of accessories	_____	
4. Labor for testing the equipment	_____	
5. Miscellaneous labor	_____	
	_____	
Total labor costs	$_____	$_____

Transportation Costs

1. Transportation for installation of control receivers	$_____	
2. Transportation for installation of transmitter equipment	_____	
3. Transportation for testing the equipment	_____	
	_____	
Total transportation costs	$_____	$_____
Total cost of installed water heater control system		$_____

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APPENDIX II

Tests On Oakdale Cooperative Electrical Association Lines

This rural distribution system was started in 1937 with 80 miles of line and 230 consumers. After approximately 12 years of operation the system has grown to 909 miles of line and 2,387 consumers.

The system is located in the east central part of Wisconsin with dairying as the major farm activity. To the south and west of the center of the distribution system is heavy dairying with the average of about 20 milkers per farm. To the north and east there is some dairying; however, general farming and cranberry marsh operation predominate in the area.

An approximate survey of the saturation of various electrical appliances on the distribution system reveals the following:

Appliance:	*Percent Saturation*
Ranges	7
Water heaters, storage type	4.4
Milking machines	90
Refrigerators	60–65
Home freezers	1

TABLE I

SYSTEM AND WATER HEATER DEMAND DATA

Date	Day	System Peak		Water Heater Peak		Average Water Heater, load watts
		Kw	P. m.	Kw.	P. m.	
		HEATERS UNDER OFF-PEAK CONTROL				
Sept. 19	Friday	1,183	7:00	96.5	9:00	1,048
20	Saturday	1,173	7:00	90.7	9:00	986
21	Sunday	1,145	7:00	103.7	9:00	[1] 1,130
22	Monday	1,137	8:00	90.7	9:00	[2] 986
23	Tuesday	1,174	7:00	95.0	9:00	1,036
24	Wednesday	1,166	7:00	[3]	[3]	[3]
25	Thursday	1,189	7:00	85.0	9:00	[4] 781
26	Friday	1,181	7:00	101.0	9:00	1,100
27	Saturday	1,202	7:00	83.6	9:00	910
28	Sunday	1,094	7:00	80.4	9:00	[2] 875
29	Monday	1,130	7:00	92.2	9:00	1,000
30	Tuesday	1,123	7:00	90.7	9:00	988
		HEATERS ALLOWED TO RUN FREE—NO OFF-PEAK CONTROL				
Oct. 1	Wednesday	[3]	[3]	[3]	[3]	[3]
2	Thursday	[3]	[3]	[3]	[3]	[3]
3	Friday	1,117	7:00	41.8	8:00	[2] 456
4	Saturday	[2]	[2]	[2]	[2]	[2]
5	Sunday	1,159	7:00	44.6	8:00	485
6	Monday	1,180	7:00	46.1	8:00	491
7	Tuesday	1,109	8:00	61.9	8:00	[2] 674
8	Wednesday	1,145	7:00	47.5	8:00	517
9	Thursday	1,195	7:00	47.5	8:00	517
10	Friday	1,166	7:00	47.5	7:00	[2] 517
11	Saturday	1,217	7:00	57.6	9:00	[5] 627
12	Sunday	1,145	7:00	33.1	7:00	[6] 360
13	Monday	1,188	7:00	46.1	8:00	491
14	Tuesday	1,195	7:00	50.4	8:00	548
		HEATERS PLACED BACK ON OFF-PEAK CONTROL				
15	Wednesday	1,022	8:00	95.5	9:00	[2] 1,042
16	Thursday	1,130	7:00	105.1	9:00	1,148
17	Friday	1,131	7:00	93.6	9:00	1,020
18	Saturday	1,131	7:00	106.8	9:00	[2] 1,165
19	Sunday	1,110	7:00	105.1	9:00	1,148
20	Monday	[3]	[3]	[3]	[3]	[3]
21	Tuesday	1,139	7:00	104.0	9:00	1,133
		HEATERS ALLOWED TO RUN FREE—NO OFF-PEAK CONTROL				
22	Wednesday	1,095	7:00	47.5	8:00	517

Average pickup after 3 hours off, 1,029 watts per heater.
Average load during peak, no control, 517 watts per heater.

[1] Water heater equipment lockout 9:00 p. m.
[2] Power supply difficulties.
[3] Recording meter failure, no record.
[4] No water heater record 12:01 to 6:35 a. m.
[5] System load at 9:00 p. m. was 698.
[6] Heavy voltage fluctuations.

TABLE II

WATER HEATER AND SAMPLING METERING DATA

Size of tank	No.	Dual element		Single element (kw.)	Percent of tank class	Percent of total heaters	Sampling metering data	
		Lower (kw.)	Upper (kw.)				Number recorded	Percent of meters used
30-gallon	22	0.60	1.00	.....	55.0	20.4	3	20.0
	1	1.50	1.50	.....	2.5	0.9	.....	.....
	1	0.75	1.00	.....	2.5	0.9	.....	.....
	13	.....	.....	1.50	32.5	12.0	3	20.0
	3	.....	.....	1.00	7.5	2.8	.....	.....
Total	40	15.45	24.50	22.50	100.0	37.0	6	40.0
40-gallon	5	0.75	1.25	.....	50.0	4.6	1	6.7
	2	0.75	2.00	.....	20.0	1.9	.....	.....
	1	1.00	1.50	.....	10.0	0.9	.....	.....
	1	1.25	2.00	.....	10.0	0.9	.....	.....
	1	1.25	2.50	.....	10.0	0.9	.....	.....
Total	10	8.75	16.25	.....	100.0	9.2	1	6.7
50-gallon	37	1.00	1.50	.....	69.7	34.3	4	26.7
	2	1.00	1.00	.....	3.8	1.9	.....	.....
	3	1.50	2.00	.....	5.7	2.8	1	6.7
	1	1.25	1.50	.....	1.9	0.9	.....	.....
	1	1.25	2.00	.....	1.9	0.9	.....	.....
	5	.....	.....	2.00	9.4	4.6	1	6.7
	2	.....	.....	1.00	3.8	1.9	.....	.....
	1	.....	.....	1.50	1.9	0.9	.....	.....
	1	.....	.....	1.25	1.9	0.9	1	6.7
Total	53	46.00	67.00	14.75	100.0	49.1	7	46.7
66-gallon	1	1.50	2.50	.....	100.0	0.9	.....	.....
Total	1	1.50	2.50	.....	100.0	0.9	.....	.....
80-gallon	3	1.50	2.50	.....	75.0	2.8	[1] 1	6.7
	1	1.50	2.00	.....	25.0	0.9	.....	.....
Total	4	6.00	9.50	.....	100.0	3.7	1	6.7
Grand total	108	77.70	119.75	37.25	.....	[2] 99.9	15	[2] 100.1

Average of lower elements=1,064 watts per heater.
Average of upper elements=1,109 watts per heater.
Average tank size=43 gallons per heater.

[1] Recording meter was changed from one heater to another during test period.
[2] Does not total 100 percent due to carrying only one decimal point.

TABLE III

DATA ON SAMPLE HEATER INSTALLATIONS

Receiver No. 2

Heater Specifications: 30 gallon; single element, 1,500 watts.

Farm Activities: Used in farm household of 3 adults. House not equipped with bathroom. Main farm activity is dairying with approximately 15 cows. Hot water is used in cleaning the dairy utensils. Heater is adequate for present needs.

Following is listing of total kilowatt-hours billed to the farmstead for the past 11 months:

November 1946	294	May 1947	261
December 1946	305	June 1947	295
January 1947	314	July 1947	290
February 1947	310	August 1947	348
March 1947	271	September 1947	391
April 1947	248		

Heater installed January 1946

Receiver No. 33

Heater Specifications: 30 gallon; dual element, 600 watt lower element, 1,000 watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household of 2 adults and 1 baby. House is equipped with a bathroom. Main farm activity is dairying with approximately 14 cows. Hot water is used in cleaning the dairy utensils. Laundry is done twice weekly with standard washing machine. Hot water is adequate for all present needs.

Following is listing of total kilowatt-hours billed to the farmstead for the past 13 months.

September 1946	136	April 1947	152
October 1946	61	May 1947	149
November 1946	143	June 1947	125
December 1946	154	July 1947	159
January 1947	161	August 1947	200
February 1947	142	September 1947	306
March 1947	174		

Heater installed March 1946

Receiver No. 34

Heater Specifications: 30 gallon; dual element, 600 watt lower element, 1,000 watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household of 3 adults and 4 school-age children. House is equipped with a bathroom. Main farm activity is dairying with approximately 19 cows. Hot water is also supplied for cleaning the dairy utensils. Weekly household laundry with standard washing machine.

Following is listing of total kilowatt-hours billed to the farmstead for the past 11 months:

November 1946	411	May 1947	420
December 1946	351	June 1947	380
January 1947	423	July 1947	420
February 1947	432	August 1947	400
March 1947	425	September 1947	418
April 1947	444		

Heater Installed in 1942

Receiver No. 52

Heater Specifications: 30 gallon; single element, 1,500 watts.

Farm Activities: Used in farm household of 3 adults. House is equipped with a bathroom. Main farm activity is dairying with approximately 25 cows. Hot water is also supplied for cleaning the dairy utensils. Present supply of hot water is not adequate.

Following is listing of total kilowatt-hours billed to the farmstead for the past 12 months:

October 1946	658	April 1947	757
November 1946	834	May 1947	725
December 1946	855	June 1947	694
January 1947	752	July 1947	672
February 1947	739	August 1947	727
March 1947	812	September 1947	800

Heater Installed March 1946

Receiver No. 27

Heater Specifications: 50 gallon; dual element, 1,500-watt lower element, 2,000-watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household of 2 adults and 7 school-age children. House is equipped with a bathroom. Main farm activity is dairying with approximately 25 cows. Hot water is also used for cleaning the dairy utensils. Heater is adequate.

Following is listing of total kilowatt-hours billed to the farmstead for the past 7 months:

March 1947	694	July 1947	992
April 1947	651	August 1947	608
May 1947	637	September 1947	620
June 1947	616		

Heater Installed March 1947

Receiver No. 30

Heater Specifications: 50 gallon; dual element, 1,000-watt lower element, 1,500-watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household of 2 adults and 5 children. House is equipped with a bathroom. Main farm activity is dairying with approximately 20 cows. Hot water is also used for cleaning dairy utensils. Heater is barely adequate. Water is only warm in late forenoon on some days. Housewife stated that a larger heater was needed.

Following is listing of total kilowatt-hours billed to the farmstead for the past 12 months:

October 1946	177	April 1947	590
November 1946	264	May 1947	697
December 1946	256	June 1947	692
January 1947	233	July 1947	582
February 1947	197	August 1947	669
March 1947	539	September 1947	553

Heater Installed March 1947

TABLE III—Continued

Receiver No. 22

Heater Specifications: 50 gallon; single element, 1,250 watts.

Farm Activities: This heater is installed in an urban home of a retired farm couple. The activities of the household do not include farm activities. Normal use of the heater is in household of 2 adults. Laundry is done for 3. House is equipped with a bathroom. Heater is adequate for all needs.

Following is listing of total kilowatt-hours billed the household for the past 12 months:

October 1946	43	April 1947	214
November 1946	48	May 1947	195
December 1946	80	June 1947	183
January 1947	202	July 1947	181
February 1947	190	August 1947	179
March 1947	251	September 1947	177

Heater Installed in January 1947

Receiver No. 62

Heater Specifications: 50 gallon; dual element, 1,000-watt lower element, 1,500-watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household of 5 adults. House is not equipped with either bathtub or shower. Laundry is done for a total of 7 adults in standard washing machine. Main farm activity is dairying with approximately 19 cows. Hot water is also used for cleaning the dairy utensils. Heater is adequate for present needs.

Following is listing of total kilowatt-hours billed to the farmstead for the past 12 months:

October 1946	242	April 1947	176
November 1946	268	May 1947	183
December 1946	288	June 1947	207
January 1947	238	July 1947	363
February 1947	233	August 1947	452
March 1947	200	September 1947	492

Heater Installed July 1947

Receiver No. 66

Heater Specifications: 50 gallon; single element, 2,000 watts.

Farm Activities: Used in farm household of 4 adults and 6 children. House is not equipped with either bathtub or shower. Laundry is done in standard washing machine twice weekly. Main farm activity is dairying with approximately 20 cows. Hot water is also used for cleaning the dairy utensils. Heater is adequate for all present needs.

Following is listing of total kilowatt-hours billed for the farmstead for the past 13 months:

September 1946	99	April 1947	124
October 1946	93	May 1947	410
November 1946	132	June 1947	474
December 1946	162	July 1947	576
January 1947	154	August 1947	531
February 1947	120	September 1947	509
March 1947	132		

Heater Installed May 1947

TABLE III—Continued

Receiver No. 81

Heater Specifications: 50 gallon; dual element, 1,000-watt lower element, 1,500-watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household for 4 adults. House is equipped with bathroom. Laundry is done in standard washing machine. Main farm activity is dairying with approximately 12 cows. Hot water is also used for cleaning the dairy utensils. Heater is adequate for present needs.

Following is listing of total kilowatt-hours billed the farmstead for the past 13 months:

September 1946	141	April 1947	192
October 1946	138	May 1947	355
November 1946	150	June 1947	499
December 1946	205	July 1947	694
January 1947	180	August 1947	720
February 1947	156	September 1947	660
March 1947	172		

Heater Installed May 1947

Receiver No. 97

Heater Specifications: 50 gallon; dual element, 1,000-watt lower element, 1,500-watt upper element. Interconnected thermostats.

Farm Activities: Used in village residential dwelling. Household consisted of 4 adults. House was equipped with a bathroom. Laundry was done with standard washing machine. Supply of hot water is adequate for all present needs.

Following is listing of total kilowatt-hours billed to the residence for the past 12 months:

October 1946	103	April 1947	88
November 1946	123	May 1947	253
December 1946	122	June 1947	378
January 1947	111	July 1947	383
February 1947	89	August 1947	451
March 1947	100	September 1947	400

Heater Installed May 1947

Receiver No. 1

Heater Specifications: 40 gallon; dual element, 750-watt lower element, 1,250-watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household of 2 adults. Main farm activity is dairying. Hot water for dairy use is supplied by separate heater in dairy barn. House is equipped with a bathroom. Heater is adequate for all present needs.

Following is listing of total kilowatt-hours billed the farmstead for the past 12 months:

November 1946	412	May 1947	604
December 1946	479	June 1947	596
January 1947	467	July 1947	564
February 1947	449	August 1947	472
March 1947	469	September 1947	564
April 1947	610	October 1947	502

Heater Installed In 1942

Receiver No. 57

Heater Specifications: 30 gallon; single element, 1,500 watts.

Farm Activities: Used in farm household of 5 adults and 4 children, including a baby. House is equipped with a bathroom. Main farm activity is dairying with approximately 15 cows. Hot water for cleaning dairy utensils is supplied by the same heater. Supply of hot water is barely adequate.

Following is listing of total kilowatt-hours billed the farmstead for the past 13 months:

September 1946	530	April 1947	766
October 1946	594	May 1947	1,000
November 1946	700	June 1947	800
December 1946	700	July 1947	550
January 1947	700	August 1947	900
February 1947	700	September 1947	900
March 1947	650		

Heater Installed March 1946

Receiver No. 17

Heater Specifications: 80 gallon; dual element, 1,500-watt lower element, 2,500-watt upper element. Interconnected thermostats.

Farm Activities: Used in residence of owner of large cranberry bog. Household consists of 3 adults and 2 children. House is equipped with 2 bathrooms. Laundry is done on automatic washing machine. Observation of laundry procedure revealed that as many as 15 loads of laundry were run through the machine in one day. On such days the hot water supply is not adequate. Water heater is metered separately.

Following is listing of kilowatt-hours billed on both residential and water-heater meters for past 10 months:

	Household		*Household*	*Heater*
November 1946	327	May 1947	842	594
December 1946	[1] 976	June 1947	1,310	535
January 1947	[1] 1,070	July 1947	854	610
February 1947	[1] 936	August 1947	893	555
March 1947	[1] 964	September 1947	917	584
April 1947	[1] 1,072			

Heater Installed December 1946

[1] Includes water heater kilowatt-hours. Meter on heater installed in May 1947.

Receiver No. 50

Heater Specifications: 30 gallon; dual element, 600-watt lower element, 1,000-watt upper element. Interconnected thermostats.

Farm Activities: Used in village residence of 4 adults and 1 baby. The heater was supplying hot water for separate weekly laundry for the 2 families. After October 30, the household consisted of only 3 adults. There were no farm activities connected with this residence. House equipped with bathroom and extra shower in basement. Heater was barely adequate.

Following is listing of total kilowatt-hours billed the residence for the past 11 months:

November 1946	337	May 1947	665
December 1946	498	June 1947	528
January 1947	677	July 1947	562
February 1947	627	August 1947	624
March 1947	676	September 1947	629
April 1947	673		

Heater Installed January 1947

Receiver No. 98

Heater Specifications: 80 gallon; dual element, 1,500-watt lower element, 2,500 watt upper element. Interconnected thermostats.

Farm Activities: Used in farm household of 4 adults. The house was equipped with a bathroom. Hot water used for normal household uses plus supplying water to wash dairy utensils. Main farm activity is dairying with approximately 20 cows. Supply of hot water is adequate for present needs.

Following is listing of total kilowatt-hours billed the farmstead for the past 11 months:

November 1946	143	May 1947	228
December 1946	168	June 1947	273
January 1947	158	July 1947	569
February 1947	182	August 1947	592
March 1947	214	September 1947	547
April 1947	215		

Heater Installed July 1947

TABLE IV

SAMPLE HEATER RECORDS

Date	Day	No. 2—30 gallons		No. 33—30 gallons		No. 34—30 gallons		No. 52—30 gallons	
		Lower, 1.5	Upper, none	Lower, 0.6	Upper, 1.0	Lower, 0.6	Upper, 1.0	Lower, 1.5	Upper, none
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Sept. 19	Friday	(1)		11 09		9 16		10 55	
20	Saturday	(1)		11 57		14 35	0 42	10 36	
21	Sunday	(1)		11 47		5 21	0 11	6 01	
22	Monday	(1)		14 02		6 12	6 26	8 00	
23	Tuesday	3 01		11 58		9 31		8 30	
24	Wednesday	2 29		8 41		7 31		8 08	
25	Thursday	2 31		5 26		6 12		7 53	
26	Friday	2 58		8 41		6 35		10 53	
27	Saturday	2 10		5 46		10 56		10 51	
28	Sunday	2 25		7 43		(1)		8 34	
29	Monday	2 47		6 52		(1)		9 51	
30	Tuesday	5 11		7 36		8 50		8 45	
Oct. 1	Wednesday	4 35		8 06		7 39		10 14	
2	Thursday	3 29		6 56		7 53		9 05	
3	Friday	6 13		11 02	1 53	6 50		10 02	
4	Saturday	3 49		7 55		8 56		11 22	
5	Sunday	1 49		5 36		15 51		11 16	
6	Monday	1 12		8 01		13 57	1 59	11 05	
7	Tuesday	1 16		7 33		7 22		8 26	
8	Wednesday	1 27		8 58		9 40		13 11	
9	Thursday	1 53		7 36		7 17		(1)	
10	Friday	3 01		4 06		5 58		(1)	
11	Saturday	3 17		8 26		13 31		12 36	
12	Sunday	2 14		9 37		13 32		8 04	
13	Monday	2 38		13 08	1 13	14 38	2 23	11 03	
14	Tuesday	2 31		10 04		9 54		11 19	
15	Wednesday	1 52		10 54		10 06		6 31	
16	Thursday	3 04		7 44		8 13		11 31	
17	Friday	2 52		8 49		8 33		9 24	
18	Saturday	7 03		10 52		11 48	0 45	11 24	
19	Sunday	3 18		6 32		16 17	0 41	7 55	
20	Monday	2 46		7 00		17 11	2 51	12 25	
21	Tuesday	1 45		10 04		11 30		11 03	
22	Wednesday	1 20		16 41	2 13	11 44	0 28	13 59	
Hours in use		86 56		307 18	5 19	323 19	16 26	320 52	
Days of record		30		34		32		32	
Kw.-h./month (30-day)		130		168		185		452	

[1] No record due to power failure or failure of recording meter.

TABLE IV—Continued

SAMPLE HEATER RECORDS

Date	Day	No. 27—50 gallons		No. 30—50 gallons		No. 32—50 gallons		No. 62—50 gallons	
		Lower, 1.5	Upper, 2.0	Lower, 1.0	Upper, 1.5	Lower, 1.25	Upper, none	Lower, 1.0	Upper, 1.5
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Sept. 19	Friday	6 27	.....	9 56	.....	3 26	.....	4 08	.....
20	Saturday	7 47	.....	12 16	0 46	3 50	.....	6 50	.....
21	Sunday	[1]	.....	[1]	.....	2 50	.....	2 00	.....
22	Monday	8 15	0 19	[1]	.....	[1]	.....	[1]	.....
23	Tuesday	5 39	.....	9 54	.....	[1]	.....	5 19	.....
24	Wednesday	5 18	.....	12 00	.....	2 44	.....	6 12	.....
25	Thursday	5 48	.....	11 39	.....	3 20	.....	9 49	.....
26	Friday	4 53	.....	11 11	.....	[1]	.....	5 52	.....
27	Saturday	6 33	.....	12 59	1 32	3 39	.....	13 28	.....
28	Sunday	5 16	.....	13 09	.....	2 19	.....	7 04	.....
29	Monday	5 31	.....	12 32	1 39	5 49	.....	6 18	.....
30	Tuesday	4 50	.....	8 50	.....	3 10	.....	8 30	.....
Oct. 1	Wednesday	[1]	.....	9 54	.....	3 37	.....	7 40	.....
2	Thursday	[1]	.....	9 02	.....	2 47	.....	7 15	.....
3	Friday	4 15	.....	9 06	.....	3 12	.....	7 39	.....
4	Saturday	9 32	0 43	12 27	.....	4 06	.....	12 36	.....
5	Sunday	4 34	.....	11 37	.....	2 33	.....	5 22	.....
6	Monday	4 26	.....	12 32	0 44	[1]	.....	5 36	.....
7	Tuesday	4 56	.....	6 46	.....	[1]	.....	7 21	.....
8	Wednesday	5 50	.....	8 28	.....	[1]	.....	[1]	.....
9	Thursday	10 13	0 41	9 52	.....	2 40	.....	[1]	.....
10	Friday	6 27	.....	9 57	.....	3 37	.....	[1]	.....
11	Saturday	8 33	.....	16 09	0 49	5 07	.....	[1]	.....
12	Sunday	5 46	.....	10 04	.....	2 49	.....	[1]	.....
13	Monday	5 32	.....	13 14	1 26	7 34	.....	[1]	.....
14	Tuesday	4 46	.....	9 23	.....	2 47	.....	15 55	.....
15	Wednesday	4 58	.....	10 28	.....	3 18	.....	14 05	.....
16	Thursday	5 08	.....	7 15	.....	3 04	.....	13 16	.....
17	Friday	8 54	0 16	7 54	.....	[1]	.....	10 09	.....
18	Saturday	8 58	.....	8 52	1 09	4 04	.....	14 07	0 27
19	Sunday	4 38	.....	13 20	0 26	2 57	.....	5 41	.....
20	Monday	6 35	.....	12 42	1 30	3 45	.....	6 42	.....
21	Tuesday	4 35	.....	9 22	.....	3 49	.....	11 34	.....
22	Wednesday	5 00	.....	11 31	.....	3 33	.....	9 17	.....
Hours in use		189 53	1 59	344 21	10 01	96 26	.....	229 55	0 27
Days of record		31	.....	32	.....	27	.....	27	.....
Kw.-h./month (30-day)		280	.....	336	.....	134	.....	256	.....

[1] No record due to power failure or failure of recording meter.

TABLE IV—Continued

SAMPLE HEATER RECORDS

Date	Day	No. 66—50 gallons		No. 81—50 gallons		No. 97—50 gallons		No. 17—80 gallons	
		Lower 2.0	Upper, none	Lower, 1.0	Upper, 1.5	Lower, 1.0	Upper, 1.5	Lower, 1.5	Upper, 2.5
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Sept. 19	Friday	2 39	.....	[1]	.....	[1]	.....	.....	.....
20	Saturday	6 33	.....	9 52	.....	8 22	0 19	.....	.....
21	Sunday	2 00	.....	[1]	.....	[1]	.....	.....	.....
22	Monday	[1]	.....	[1]	.....	[1]	.....	.....	.....
23	Tuesday	4 12	.....	11 45	.....	6 10	.....	.....	.....
24	Wednesday	4 57	.....	8 32	.....	7 12	.....	.....	.....
25	Thursday	3 42	.....	11 48	.....	6 42	.....	.....	.....
26	Friday	5 24	.....	11 43	.....	6 29	.....	.....	.....
27	Saturday	5 36	.....	7 09	.....	13 29	1 20	.....	.....
28	Sunday	3 16	.....	7 43	.....	8 52	.....	.....	.....
29	Monday	7 37	.....	12 11	.....	6 27	.....	.....	.....
30	Tuesday	2 51	.....	8 49	.....	5 35	.....	.....	.....
Oct. 1	Wednesday	5 26	.....	7 59	.....	7 46	.....	.....	.....
2	Thursday	4 16	.....	11 39	.....	5 56	.....	.....	.....
3	Friday	6 05	.....	9 31	.....	5 54	.....	.....	.....
4	Saturday	4 39	.....	9 54	.....	12 39	.....	.....	.....
5	Sunday	4 23	.....	7 13	.....	9 22	.....	.....	.....
6	Monday	7 25	.....	13 22	.....	5 29	.....	.....	.....
7	Tuesday	3 42	.....	6 55	.....	5 28	.....	.....	.....
8	Wednesday	4 55	.....	6 23	.....	5 28	.....	.....	.....
9	Thursday	3 55	.....	6 32	.....	7 22	.....	13 26	3 05
10	Friday	5 07	.....	7 07	.....	10 53	.....	12 19	.....
11	Saturday	5 58	.....	7 19	.....	14 07	.....	11 27	.....
12	Sunday	3 08	.....	10 30	.....	7 23	.....	8 41	.....
13	Monday	6 52	.....	6 54	.....	5 51	.....	10 50	5 27
14	Tuesday	3 28	.....	11 40	.....	5 25	.....	11 10	0 15
15	Wednesday	4 53	.....	7 37	.....	5 01	.....	10 25	.....
16	Thursday	3 12	.....	8 25	.....	3 26	.....	13 55	0 18
17	Friday	4 37	.....	7 57	.....	8 24	.....	10 27	.....
18	Saturday	4 13	.....	9 19	.....	8 46	.....	8 42	.....
19	Sunday	3 17	.....	7 24	.....	8 02	.....	7 20	.....
20	Monday	6 30	.....	13 27	.....	7 23	.....	12 41	1 57
21	Tuesday	3 31	.....	8 51	.....	6 36	.....	11 18	5 29
22	Wednesday	3 25	.....	8 12	.....	6 30	.....	13 22	0 33
Hours in use		151 44	.....	283 42	.....	232 39	1 39	156 12	17 04
Days of record		33	.....	31	.....	31	.....	14	.....
Kw.-h./month (30-day)		276	.....	274	.....	228	.....	580	.....

[1] No record due to power failure or failure of recording meter.

TABLE IV—Continued

SAMPLE HEATER RECORDS

Date	Day	No. 1—40 gallons		No. 57—30 gallons		No. 50—30 gallons		No. 98—80 gallons	
		Lower 0.75	Upper 1.25	Lower 1.5	Upper none	Lower 0.6	Upper 1.0	Lower 1.5	Upper 2.5
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Sept. 19	Friday	1 51	1 27	11 45	.....	8 85	.....	6 41	.....
20	Saturday	2 56	1 56	11 33	.....	13 49	.....	5 47	.....
21	Sunday	2 19	.....	(1)	.....	(1)	.....	3 42	.....
22	Monday	4 36	2 31	(1)	.....	(1)	.....	10 47	.....
23	Tuesday	3 00	0 20	(1)	.....	17 14	0 24	4 52	.....
24	Wednesday	3 05	1 10	(1)	.....	13 23	.....	7 52	.....
25	Thursday	2 03	0 55	(1)	.....	14 06	3 13	11 34	.....
26	Friday	2 05	1 25	(1)	.....	15 16	1 07	7 48	.....
27	Saturday	3 27	0 55	(1)	.....	(1)	.....	7 02	.....
28	Sunday	2 10	.....	(1)	.....	15 39	0 20	5 42	.....
29	Monday	2 20	1 40	(1)	.....	7 50	.....	8 40	.....
30	Tuesday	1 45	0 55	12 05	.....	12 41	.....	6 03	.....
Oct. 1	Wednesday	1 05	1 00	11 52	.....	12 44	0 19	8 33	.....
2	Thursday	(1)	.....	(1)	.....	13 54	5 51	8 23	.....
3	Friday	(1)	.....	(1)	.....	(1)	.....	9 22	.....
4	Saturday	.....	.....	(1)	.....	(1)	.....	7 26	.....
5	Sunday	.....	.....	(1)	.....	(1)	.....	6 16	.....
6	Monday	.....	.....	(1)	.....	(1)	.....	12 20	.....
7	Tuesday	.....	.....	5 11	.....	(1)	.....	6 03	.....
8	Wednesday	.....	.....	9 03	.....	(1)	.....	.....	.....
9	Thursday	.....	.....	(1)	.....	(1)	.....	.....	.....
10	Friday	.....	.....	(1)	.....	(1)	.....	.....	.....
11	Saturday	.....	.....	11 51	.....	12 52	.....	.....	.....
12	Sunday	.....	.....	9 48	.....	7 27	.....	.....	.....
13	Monday	.....	.....	16 12	.....	13 32	.....	.....	.....
14	Tuesday	.....	.....	10 25	.....	7 02	.....	.....	.....
15	Wednesday	.....	.....	8 48	.....	7 17	.....	.....	.....
16	Thursday	.....	.....	14 03	.....	8 45	.....	.....	.....
17	Friday	.....	.....	9 14	.....	8 51	.....	.....	.....
18	Saturday	.....	.....	11 19	.....	9 36	.....	.....	.....
19	Sunday	.....	.....	10 18	.....	10 44	.....	.....	.....
20	Monday	.....	.....	12 45	.....	13 37	.....	.....	.....
21	Tuesday	.....	.....	(1)	.....	7 11	.....	.....	.....
22	Wednesday	.....	.....	(1)	.....	10 01	.....	.....	.....
Hours in use		32 42	14 14	176 12	.....	262 06	11 14	144 53	.....
Days of record		13	.....	16	.....	23	.....	19	.....
Kw.-h./month (30-day)		98	.....	496	.....	220	.....	343	.....

[1] No record due to power failure or failure of recording meter.

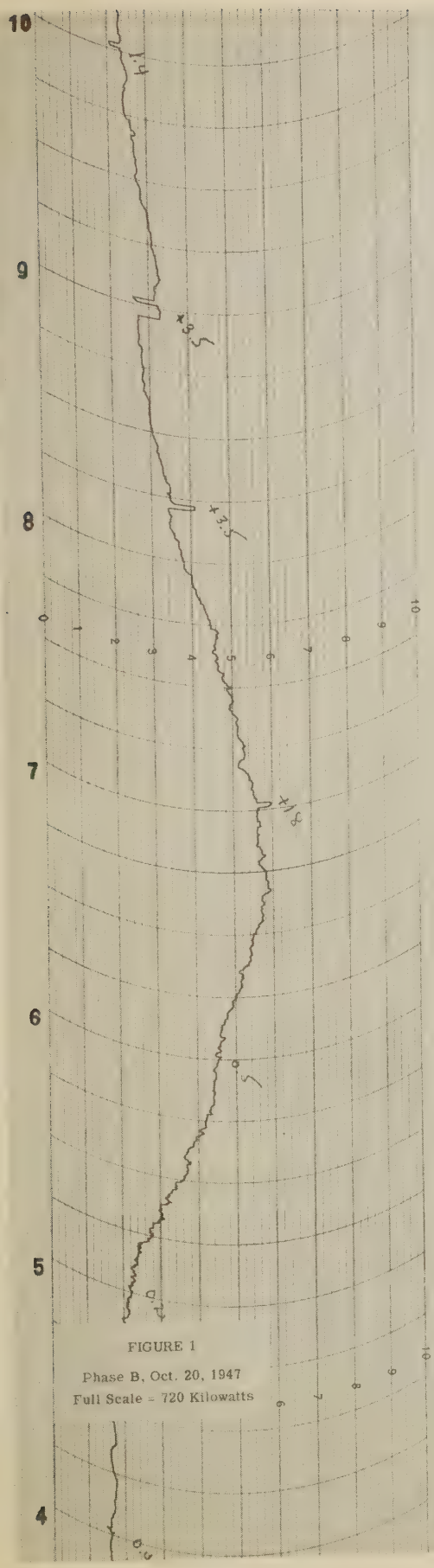

FIGURE 1

Phase B, Oct. 20, 1947

Full Scale = 720 Kilowatts

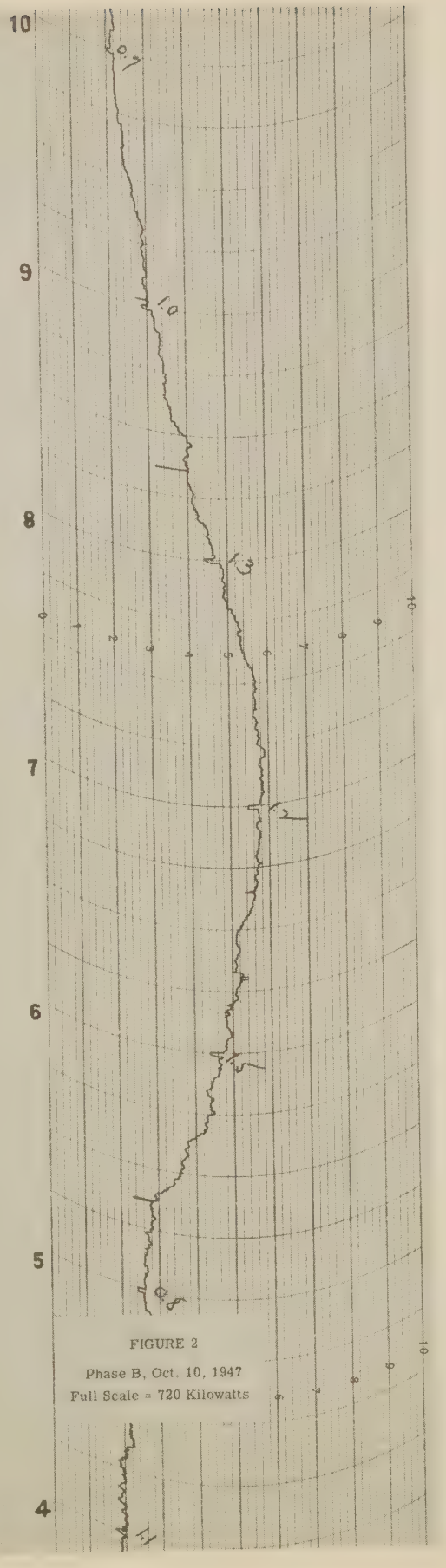

FIGURE 2

Phase B, Oct. 10, 1947

Full Scale = 720 Kilowatts

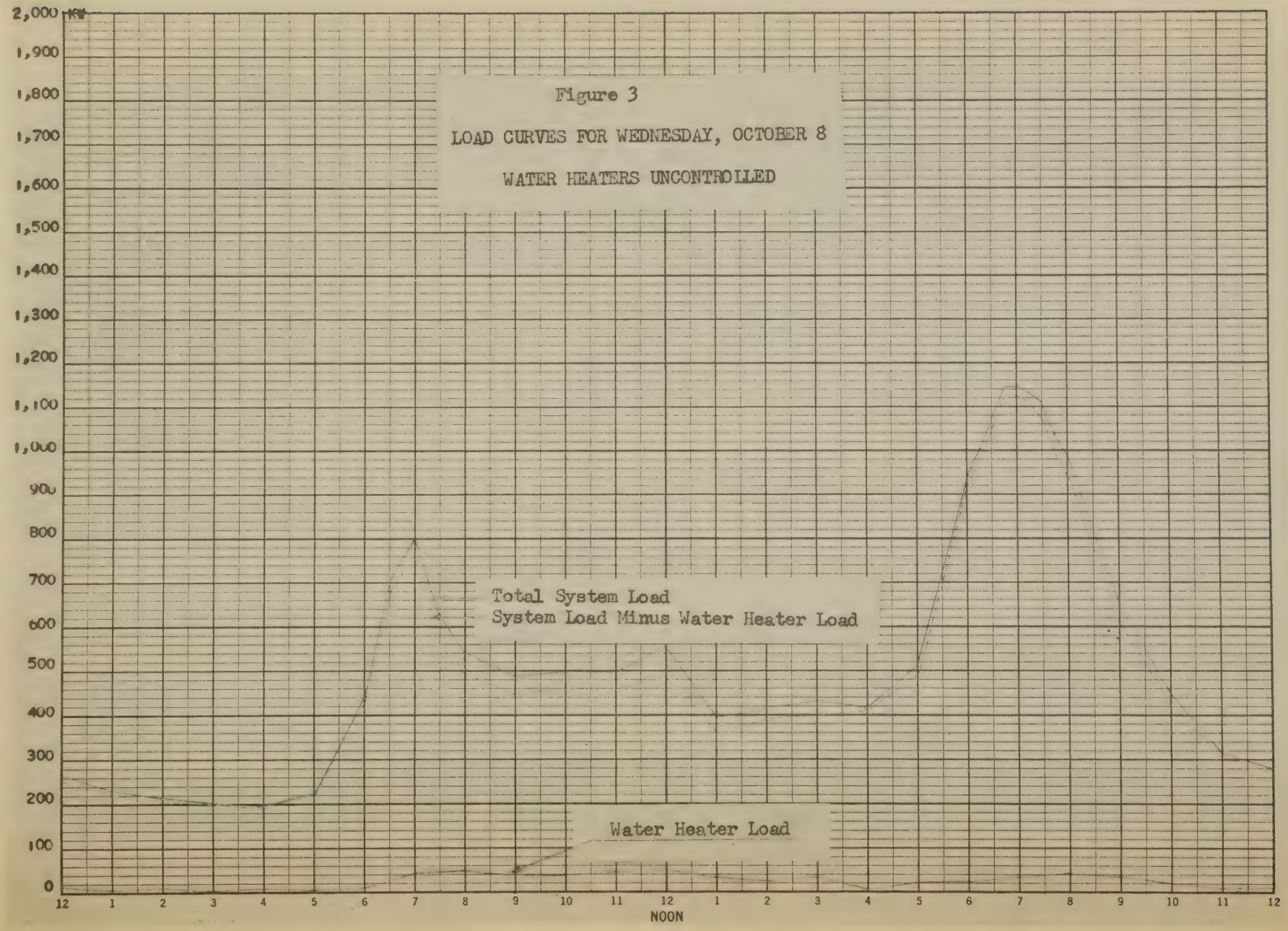
Figure 3
LOAD CURVES FOR WEDNESDAY, OCTOBER 8
WATER HEATERS UNCONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
2,000 KW
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

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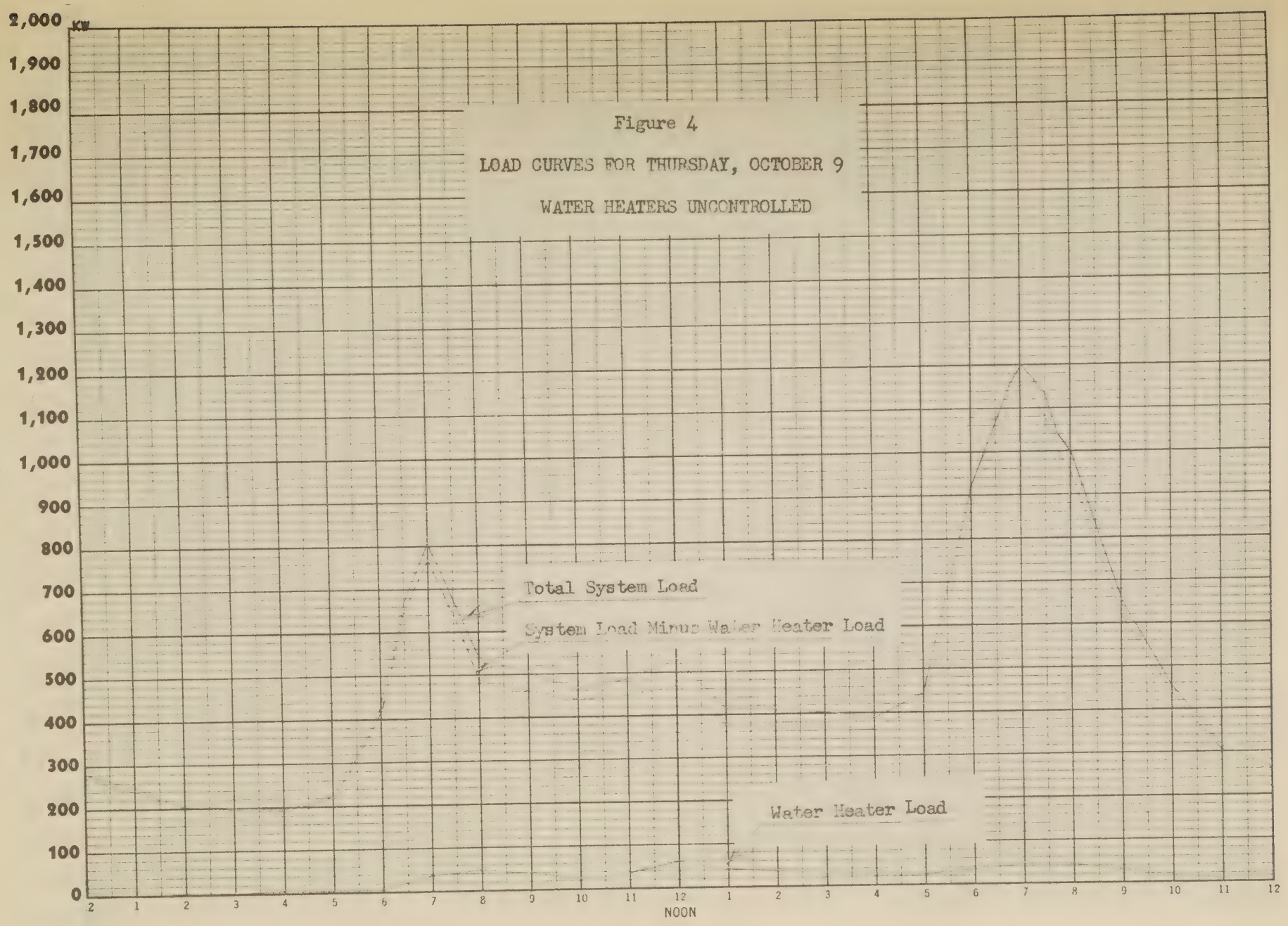
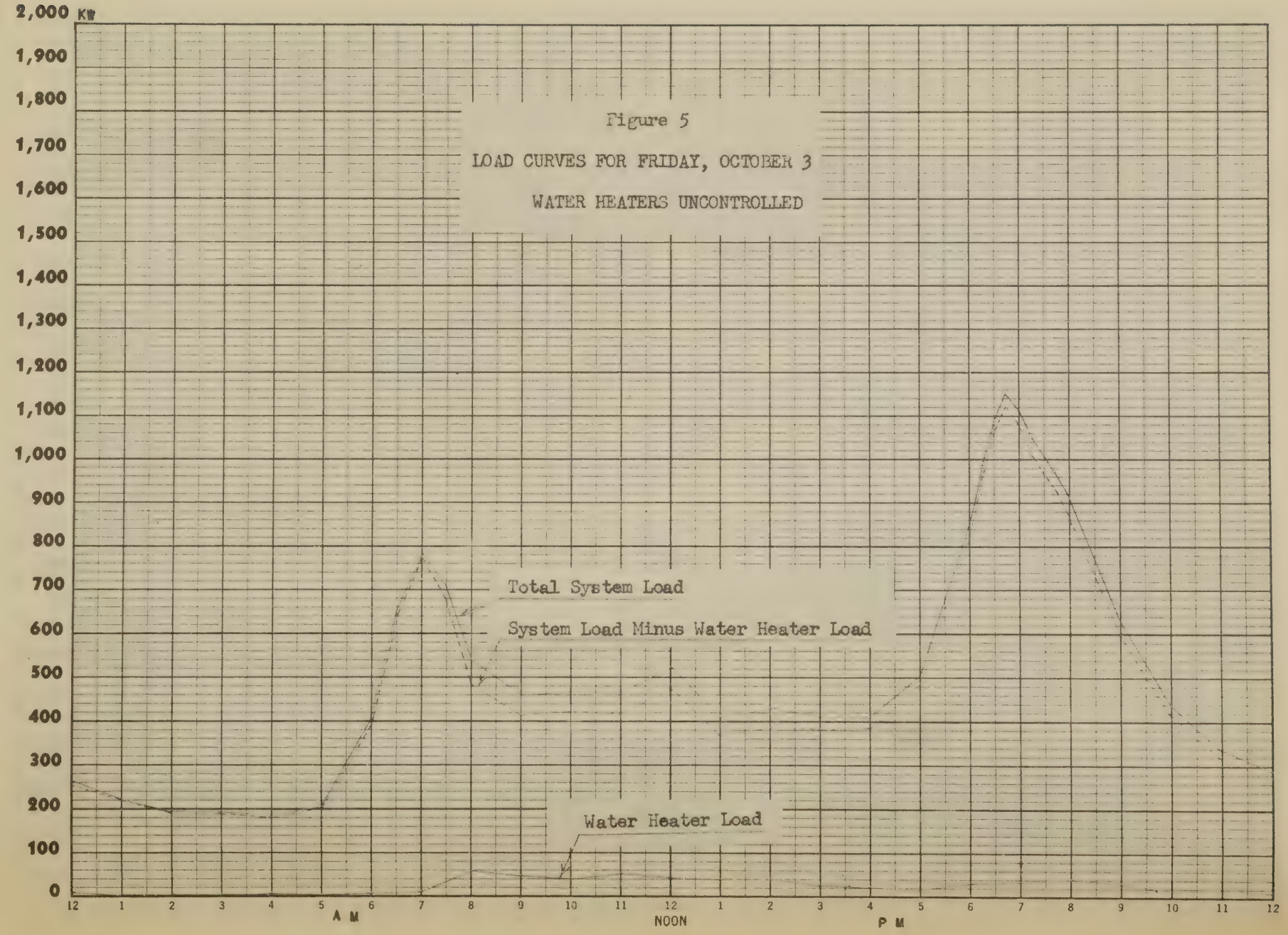
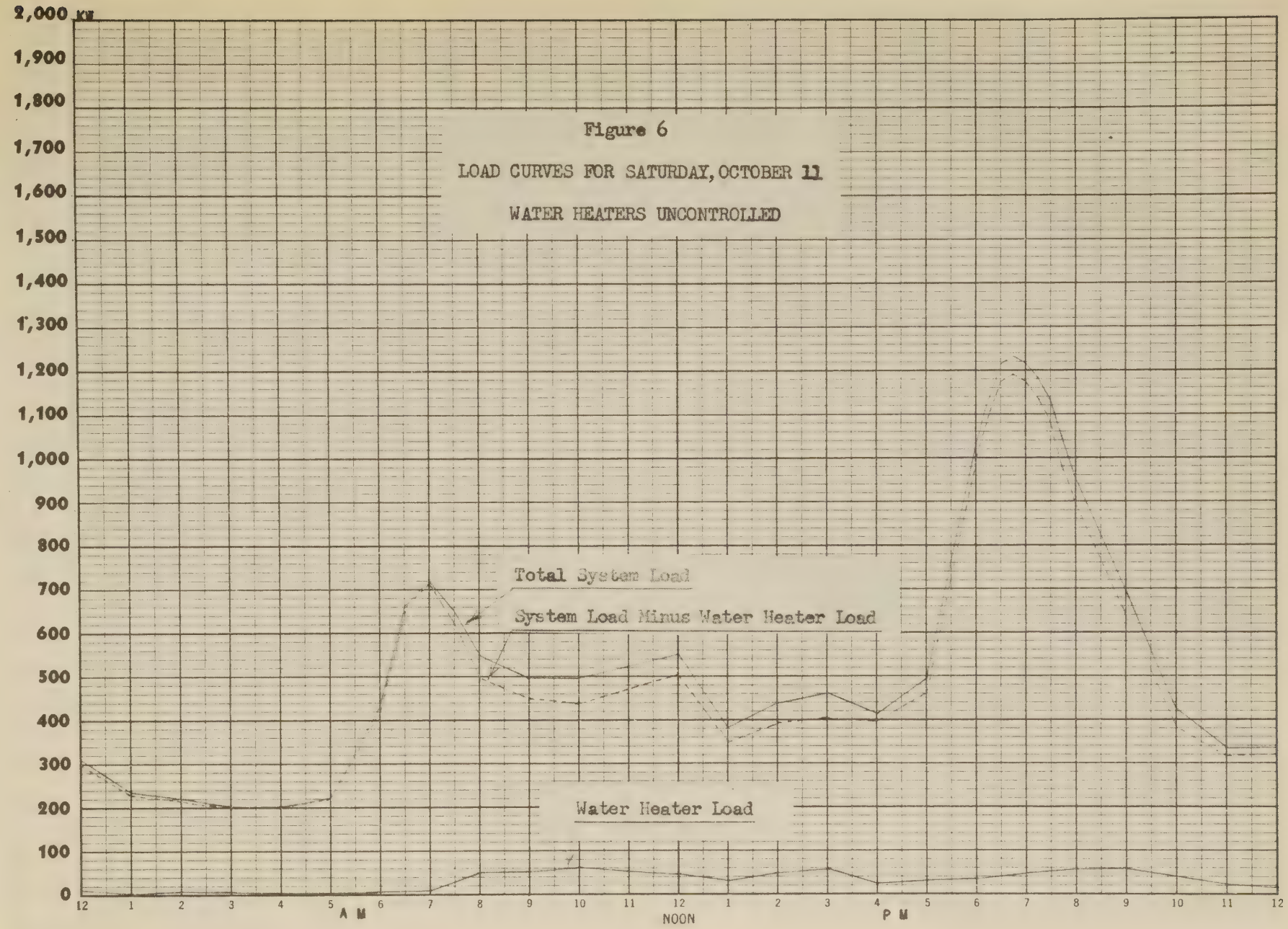
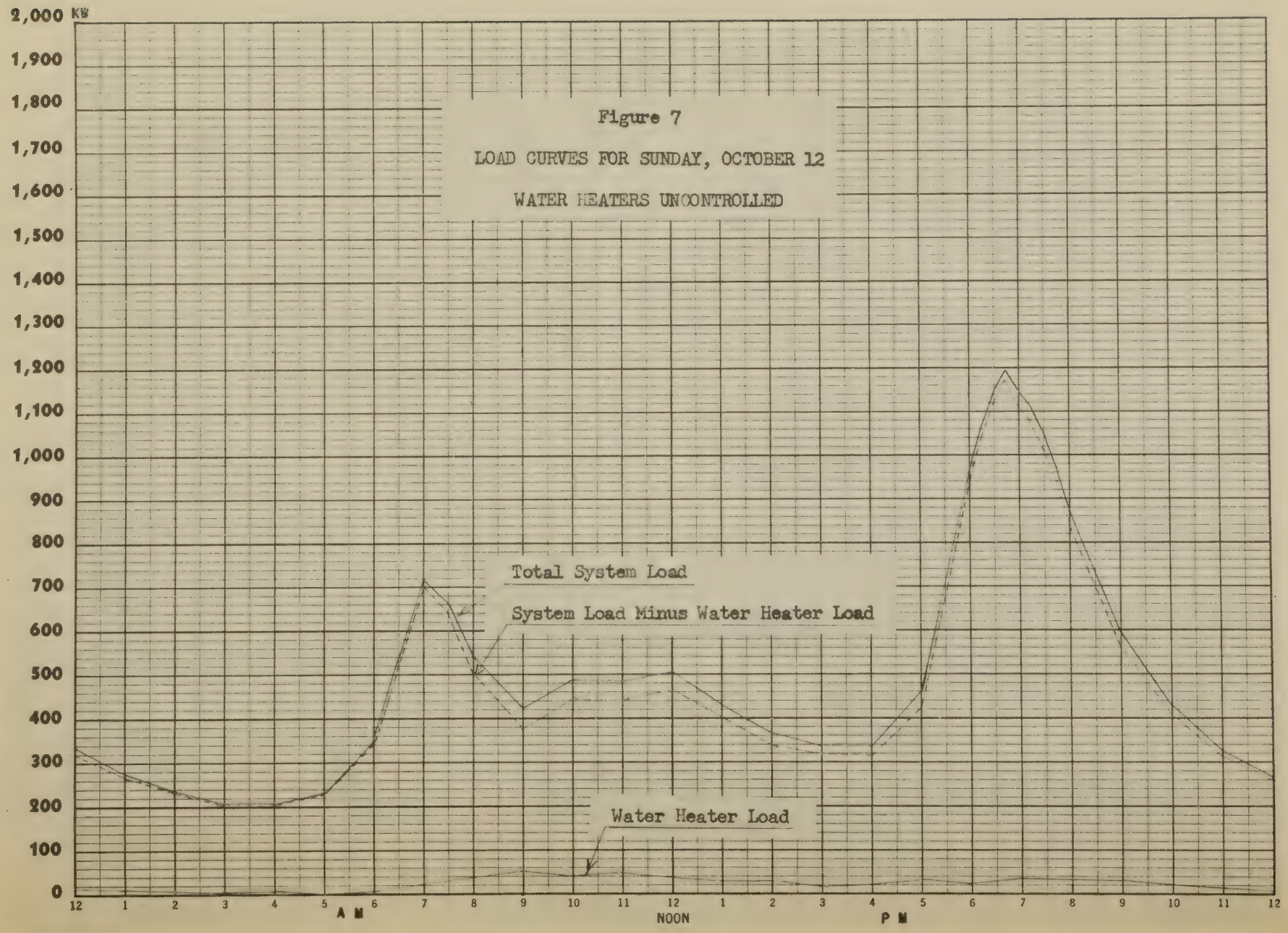


Figure 4
LOAD CURVES FOR THURSDAY, OCTOBER 9
WATER HEATERS UNCONTROLLED
KW
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Total System Load
System Load Minus Water Heater Load
Water Heater Load
2
1
2
3
4
5
6
7
8
9
10
11
12
NOON
1
2
3
4
5
6
7
8
9
10
11
12


2,000 KW
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Figure 5
LOAD CURVES FOR FRIDAY, OCTOBER 3
WATER HEATERS UNCONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M


2,000 KW
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Figure 6
LOAD CURVES FOR SATURDAY, OCTOBER 11
WATER HEATERS UNCONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M


2,000 KW
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Figure 7
LOAD CURVES FOR SUNDAY, OCTOBER 12
WATER HEATERS UNCONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M

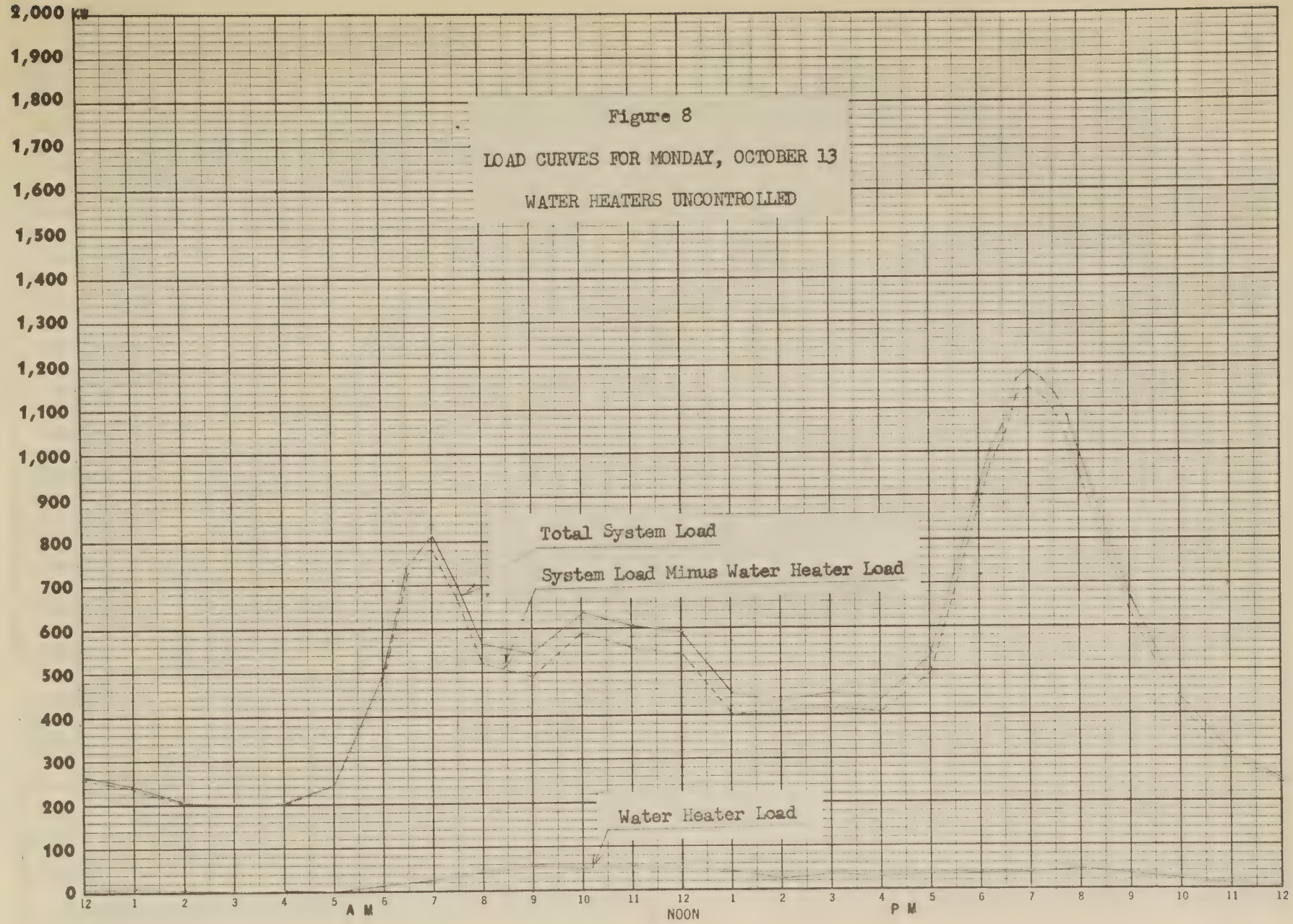


Figure 8

LOAD CURVES FOR MONDAY, OCTOBER 13

WATER HEATERS UNCONTROLLED

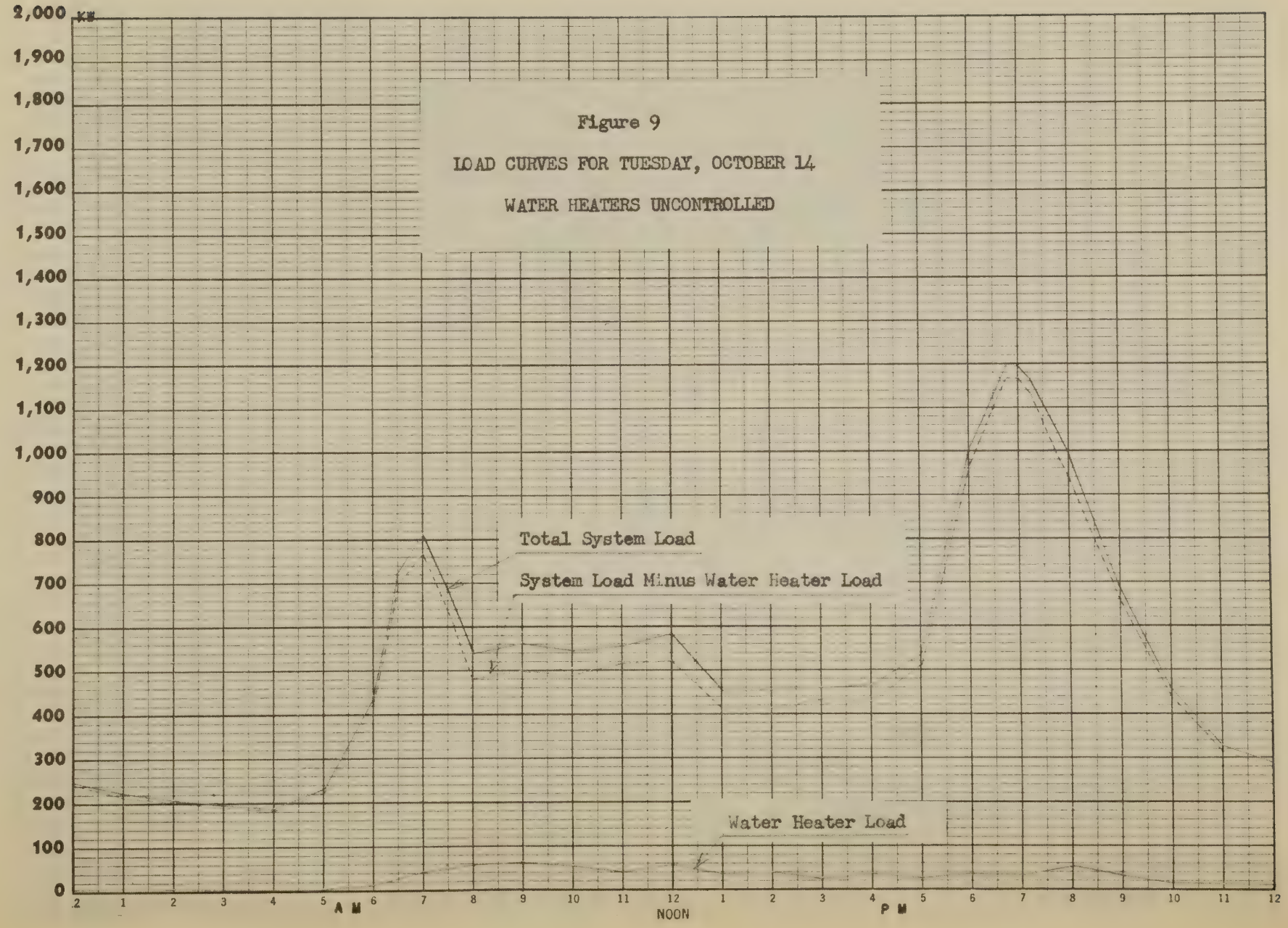


Figure 9
LOAD CURVES FOR TUESDAY, OCTOBER 14
WATER HEATERS UNCONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
KW
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M

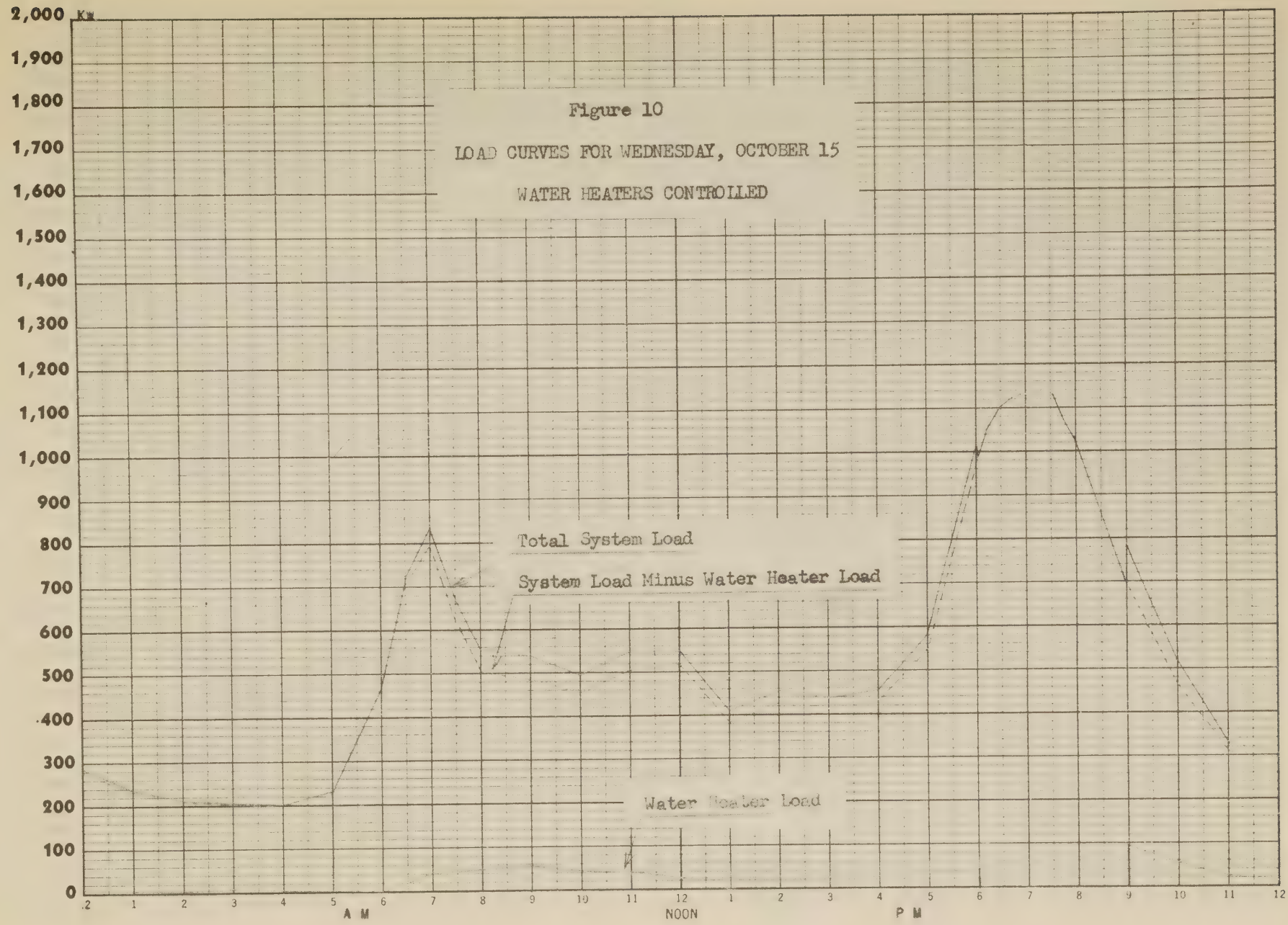


Figure 10
LOAD CURVES FOR WEDNESDAY, OCTOBER 15
WATER HEATERS CONTROLLED
Kw
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Total System Load
System Load Minus Water Heater Load
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M

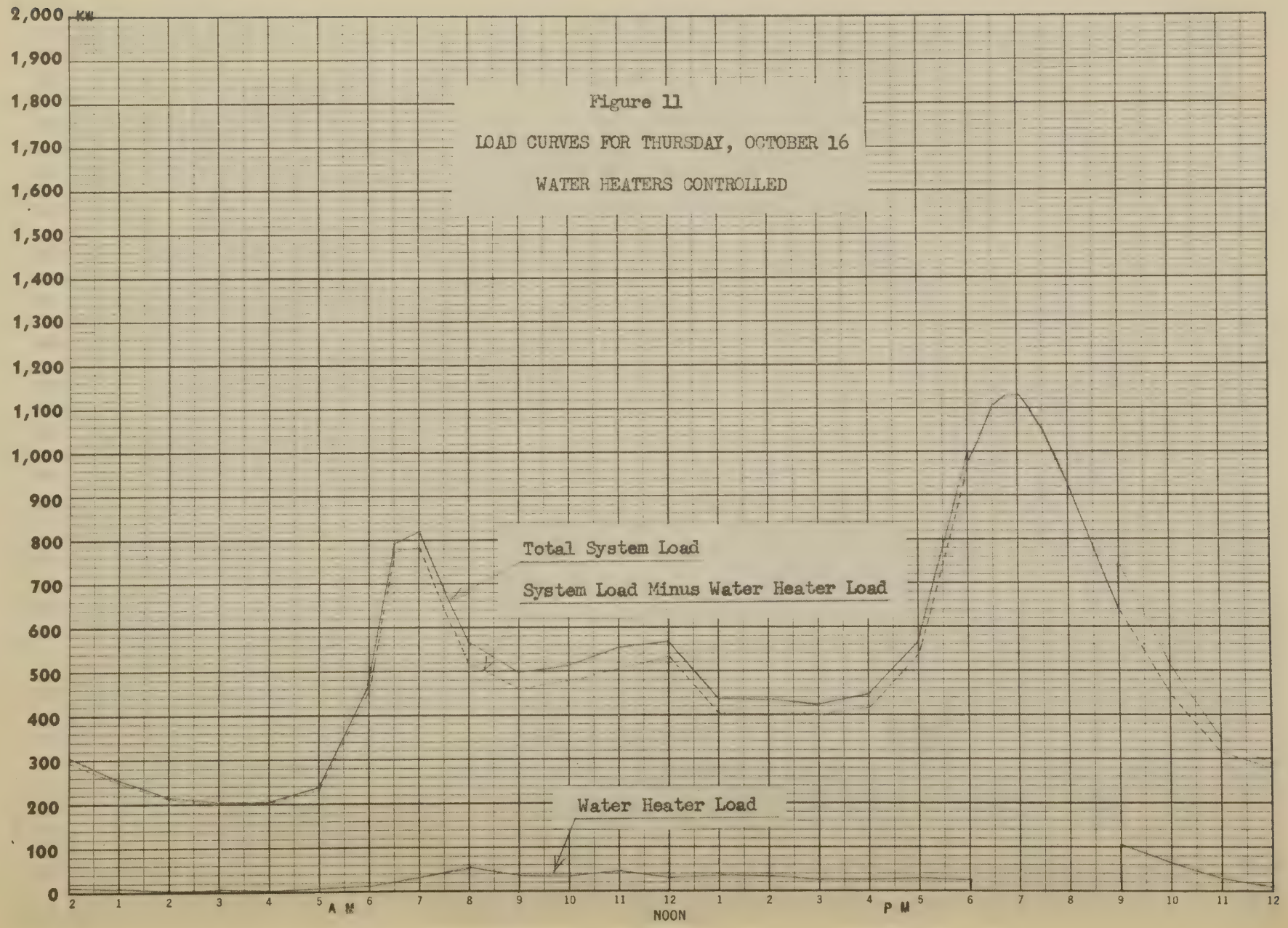


Figure 11
LOAD CURVES FOR THURSDAY, OCTOBER 16
WATER HEATERS CONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
KW
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
2 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M

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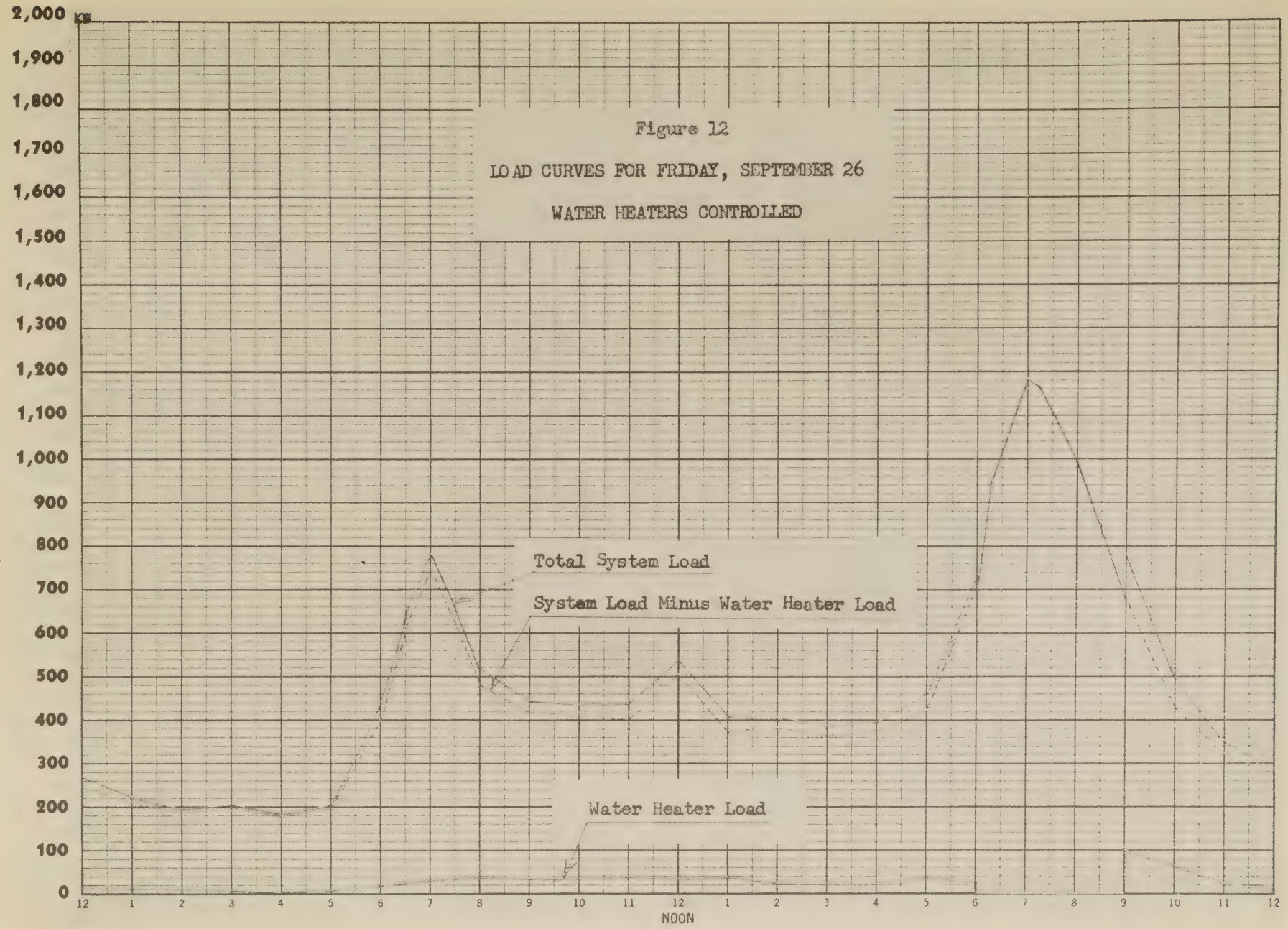


Figure 12
LOAD CURVES FOR FRIDAY, SEPTEMBER 26
WATER HEATERS CONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
KW
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

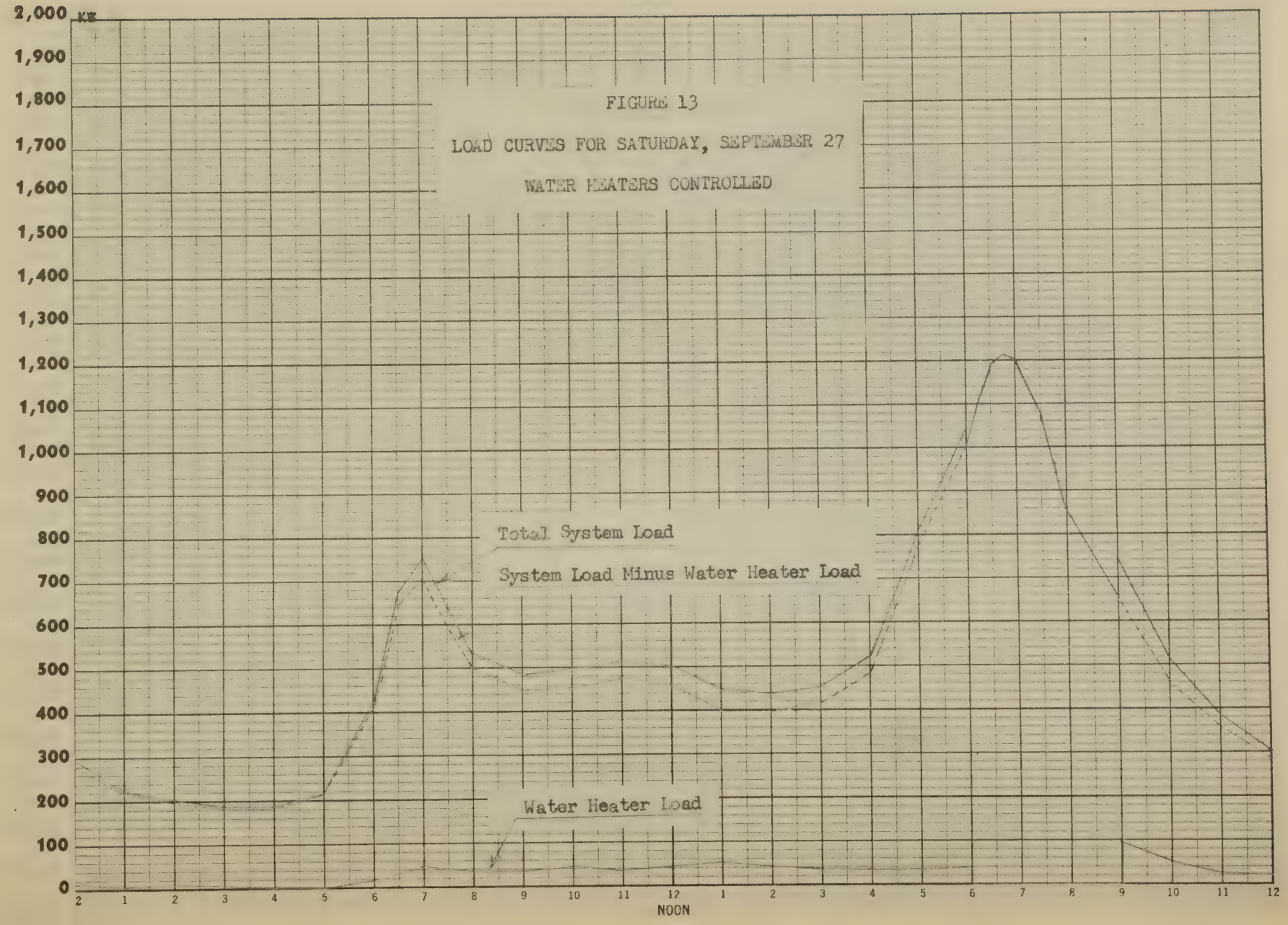


FIGURE 13
LOAD CURVES FOR SATURDAY, SEPTEMBER 27
WATER HEATERS CONTROLLED
Kw
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Total System Load
System Load Minus Water Heater Load
Water Heater Load
2 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

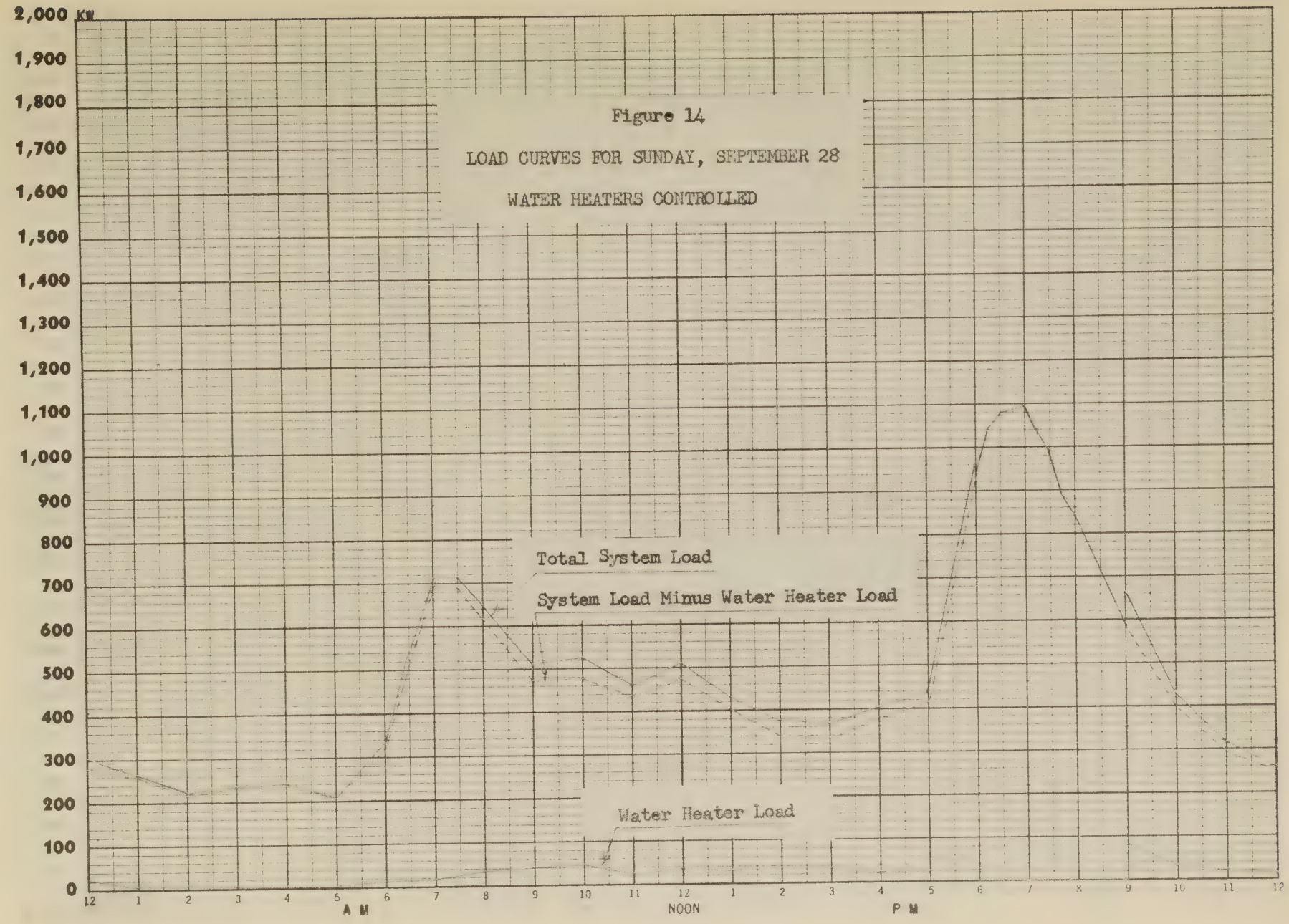


Figure 14

LOAD CURVES FOR SUNDAY, SEPTEMBER 28

WATER HEATERS CONTROLLED

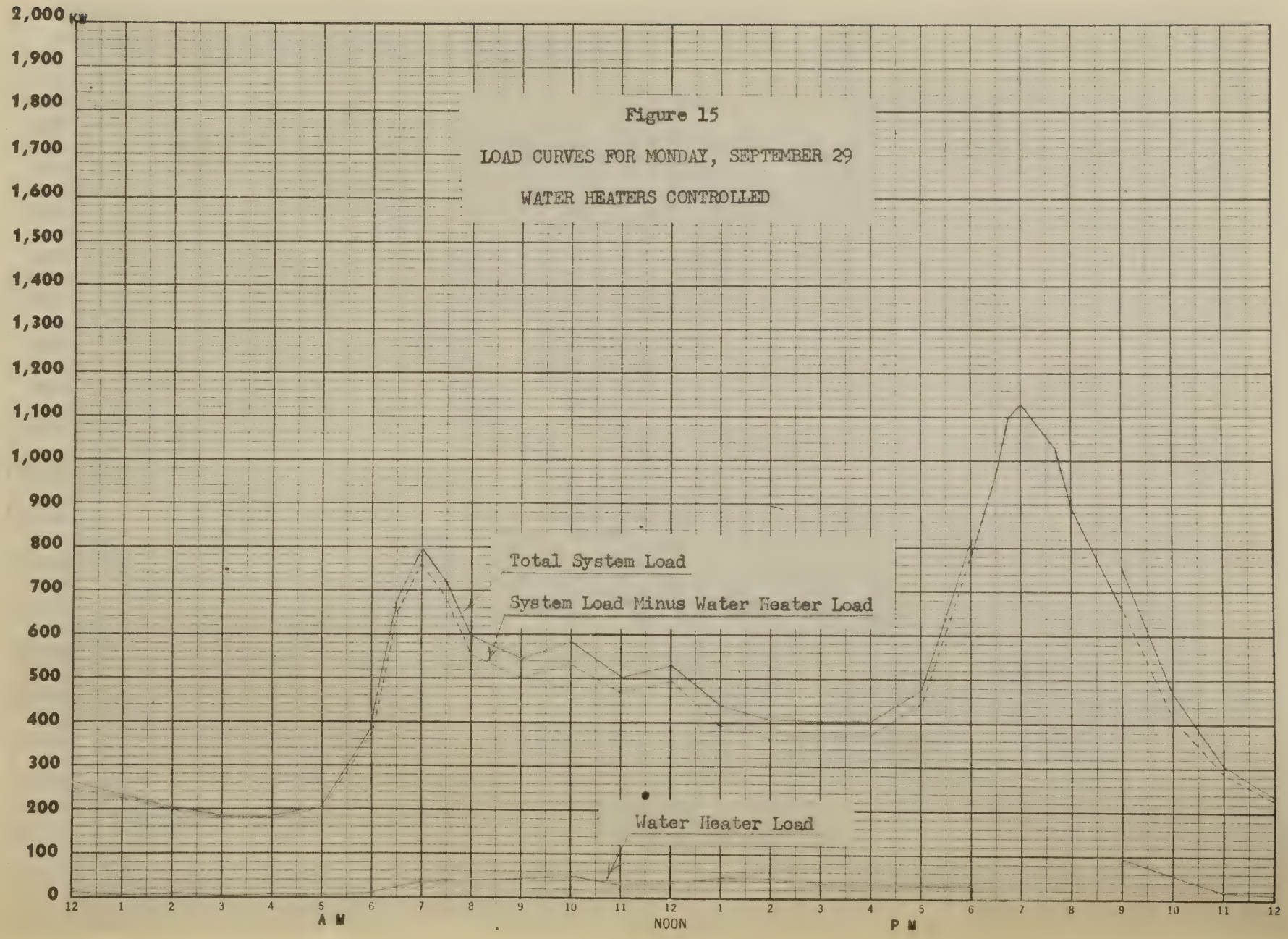
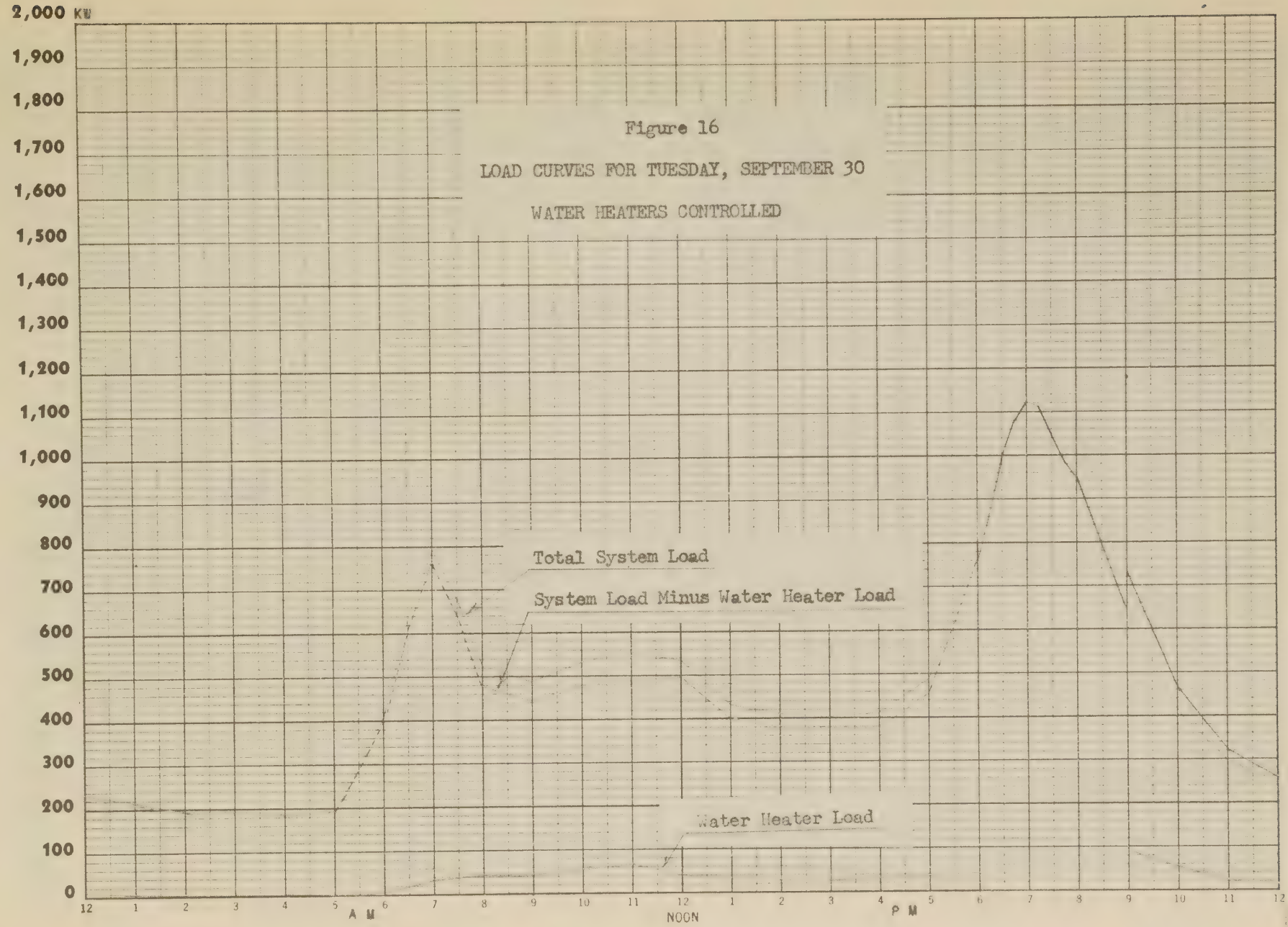


Figure 15
LOAD CURVES FOR MONDAY, SEPTEMBER 29
WATER HEATERS CONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
KW
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M


2,000 KW
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Figure 16
LOAD CURVES FOR TUESDAY, SEPTEMBER 30
WATER HEATERS CONTROLLED
Total System Load
System Load Minus Water Heater Load
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A M
NOON
P M

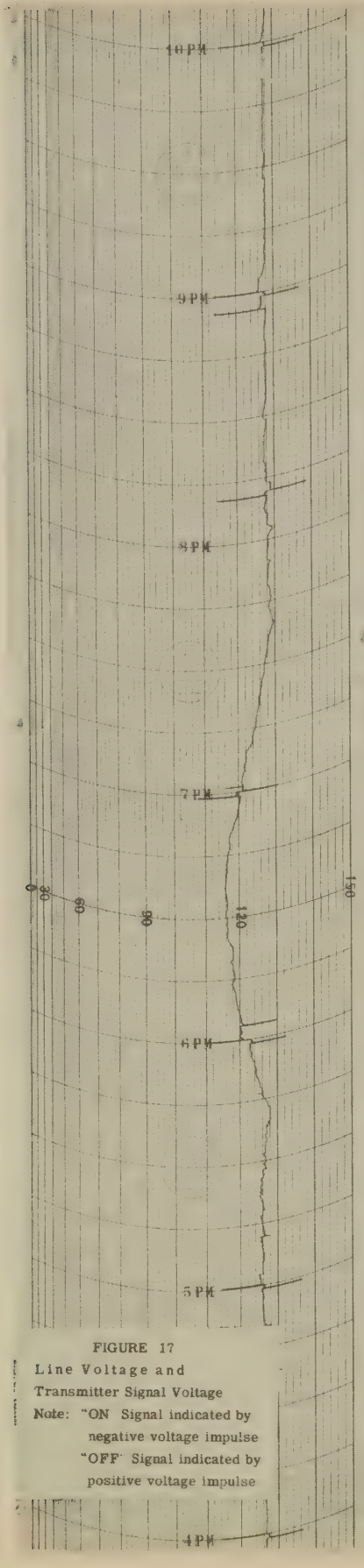


FIGURE 17
Line Voltage and
Transmitter Signal Voltage
Note: "ON Signal indicated by
negative voltage impulse
"OFF" Signal indicated by
positive voltage impulse

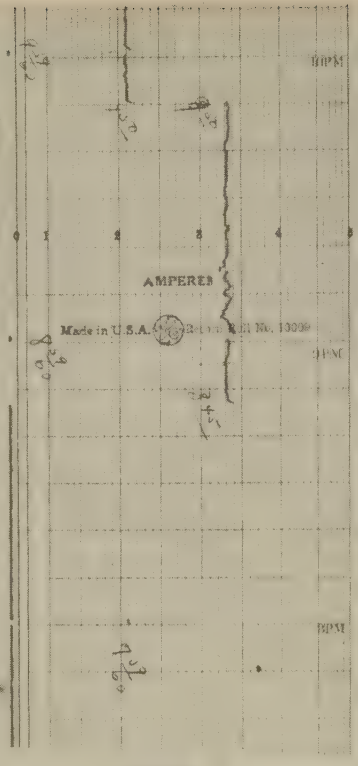
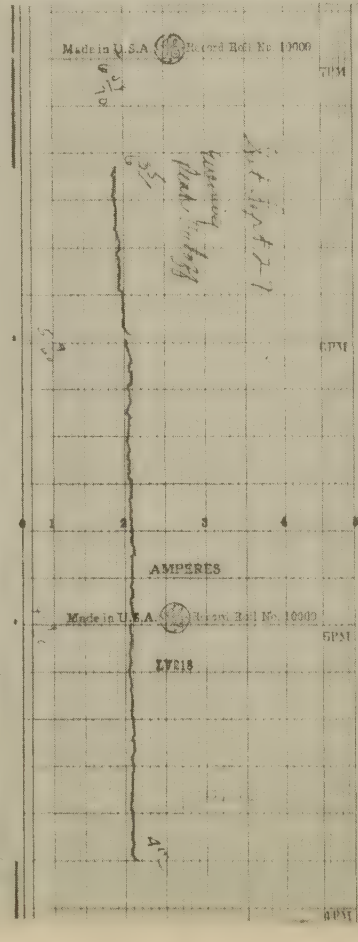


FIGURE 18
Ammeter Record for 2 Element Water Heater
Water Heaters cut off 6:35 to 8: 35 PM



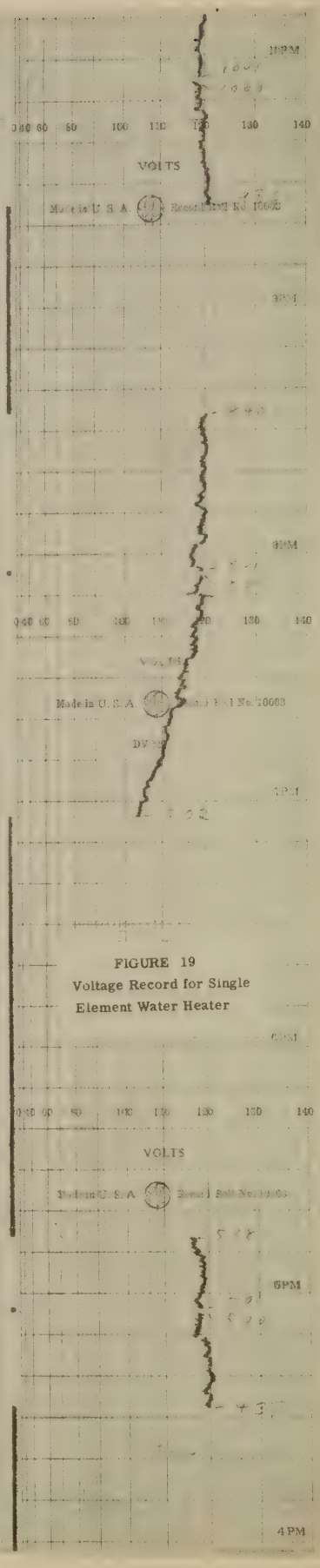


FIGURE 19
Voltage Record for Single
Element Water Heater

APPENDIX III

Tests on Steuben County Rural Electric Membership Corporation Lines

Supplementary System Information: The Steuben system was initially energized in March 1939. During 1939, 202 miles of line serving 656 consumers were energized. Other consumers were added at a fairly steady rate to reach the total of 1,693 served by 363 miles of line in November 1947. The number of electric ranges in use is estimated at 400 for November 1947. Information on the saturation of appliances other than ranges and water heaters is not available.

Consumers served by this system at the time of testing were grouped for billing and used energy in November 1947 as follows:

GROUP	NUMBER	AVERAGE KWH BILLED
Farm	1,314	182
Rural nonfarm (residential)	99	148
Small commercial and industrial	25	188
Other	255	33
All consumers	1,693	152

Most of the consumers listed as "Other" are seasonal users, many of them served at summer cottages.

TABLE 1

Tank Sizes and Element Ratings of Water Heaters in Use During Tests, Steuben County, Indiana

Number of heaters	Tank size gallons	Rating, in kilowatts	
		Lower element	Upper element
4	30	[1] 1.5	.....
2	30	[1] 2.0	.....
1	40	0.75	1.0
1	40	[1] 1.0	.....
1	40	[1] 1.25	.....
9	40	[1] 1.5	.....
4	40	[1] 2.0	.....
1	40	[1] 3.0	.....
4	50	1.0	1.5
17	50	[1] 1.5	.....
1	50	[1] 1.75	.....
11	50	[1] 2.0	.....
10	50	[1] 2.5	.....
1	50	[1] 3.0	.....
1	66	1.5	2.0
9	66	[1] 2.0	.....
3	66	[1] 2.5	.....
3	66	[1] 3.0	.....
1	80	1.0	2.0
1	80	1.5	1.5
7	80	[1] 2.0	.....
15	80	[1] 2.5	.....
1	80	[1] 2.75	.....
2	80	[1] 3.0	.....

[1] Single element heaters. Two element heaters with upper units disconnected are included as single element heaters.

TABLE II

SYSTEM AND WATER HEATER DEMANDS—STEUBEN TESTS

Date	Day	Time of system peak p. m.	Demand at time of peak			Afternoon water heater peak		Water heaters controlled [1]	
			Total kw.	Water heater kw.					
				Total	Per heater	Kw.	Time	Number	Kw.
Nov. 26	Wednesday	5:30–5:45	977	50	0.55	53	5:30	91	184
27	Thursday	5:30–5:45	875	29	.32	67	7:00	92	185
28	Friday	5:15–5:30	975	41	.45	48	7:00	92	185
29	Saturday	5:15–5:45	1,023	55	.60	62	5:30	92	185
30	Sunday	5:30–5:45	880	54	.59	58	5:30	92	185
Dec. 1	Monday	5:15–5:30	984	47	.51	58	6:00	92	185
2	Tuesday	5:00–5:15	942	42	.44	58	6:00	95	190
3	Wednesday	5:00–5:15	981	44	.44	59	7:00	100	196
4	Thursday	5:15–5:30	976	38	.38	46	8:00	100	196
5	Friday	5:15–5:30	986	42	.42	65	6:00	100	196
6	Saturday	5:30–5:45	963	49	.49	55	7:00	100	196
7	Sunday	5:30–5:45	906	46	.46	55	6:00	100	196
8	Monday	5:00–5:15	954	37	.37	50	6:00	100	196
9	Tuesday	5:15–5:30	957	47	.47	59	6:00	100	196
10	Wednesday	5:00–5:15	911	(2)	(2)	[2] 155	7:20	100	196
11	Thursday	5:00–5:15	912	(2)	(2)	[2] 156	9:00	100	196
12	Friday	5:15–5:30	934	(2)	(2)	[2] 134	7:16	100	196
13	Saturday	5:30–5:45	910	(2)	(2)	[2] 164	7:25	100	196

[1] Actual number less 10 percent. See Discussion of Test Results, p. 6.
[2] Water heaters were cut off during the afternoon peak as follows: Dec. 10, 4:50 to 7:20; Dec. 11, 4:32 to 9:00; Dec. 12, 4:40 to 7:16; Dec. 13, 4:50 to 7:25.

TABLE III

TOTAL HEATING TIME FOR INDIVIDUAL WATER HEATERS—STEUBEN TEST

Date	Day	No. 3–43 gallons		No. 6–82 gallons—Single unit, 2.75	No. 16–52 gallons—Single unit, 2.0	No. 26–52 gallons—Single unit, 1.5
		Lower 0.75	Upper 1.5			
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Nov. 19	Wednesday	(2)	(2)	[1] 1 30	(3)	(2)
20	Thursday	(2)	(2)	4 27	(2)	(2)
21	Friday	.....	[1] 2 35	6 52	[1] 1 38	(2)
22	Saturday	.....	2 23	3 37	2 14	(2)
23	Sunday	.....	2 43	6 10	3 09	(2)
24	Monday	7 44	0 58	4 50	1 49	(2)
25	Tuesday	.....	1 17	4 38	3 18	(2)
26	Wednesday	.....	1 31	4 43	3 21	(2)
27	Thursday	.....	1 56	4 02	1 36	(2)
28	Friday	.....	1 57	4 08	1 56	(2)
29	Saturday	.....	2 54	8 22	3 00	(2)
30	Sunday	6 38	1 06	1 14	1 02	(2)
Dec. 1	Monday	4 10	0 42	4 22	3 57	(2)
2	Tuesday	.....	2 06	[1] 0 36	4 10	[1] 2 27
3	Wednesday	6 32	2 02	(2)	[1] 0 52	9 32
4	Thursday	1 39	0 54	(2)	(2)	7 09
5	Friday	.....	2 37	(2)	(2)	6 09
6	Saturday	.....	2 58	(2)	(2)	9 16
7	Sunday	.....	1 59	(2)	(2)	7 49
8	Monday	3 29	0 43	(2)	(2)	8 55
9	Tuesday	.....	1 36	[1] 2 10	(2)	8 23
10	Wednesday	.....	2 01	3 25	(2)	7 15
11	Thursday	.....	2 05	4 30	(2)	8 22
12	Friday	[1] 3 36	[1] 0 41	[1] 1 50	(2)	[1] 2 09
13	Saturday	(2)	(2)	(2)	(2)	(2)
Total hours		34 08	39 44	71 26	32 02	77 26
Days of record		21.2	.....	15.8	12.2	9.9
Kwh.-/30-day month [3]		120	.....	375	155	350

[1] Less than a full 24 hour record on these days.
[2] No record on these days.
[3] Calculated from element size and total heating time.

TABLE III—Continued

TOTAL HEATING TIME FOR INDIVIDUAL WATER HEATERS—STEUBEN TEST

Date	Day	No. 30—52-gallon single unit, 2.5	No. 32—52-gallon		No. 48—66-gallon single unit, 2.0	No. 51—80-gallon single unit, 2.5	No. 56—50-gallon single unit, 2.5
			Lower 1.0	Upper 2.0			
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Nov. 19	Wednesday	(2)	(2)	(2)	(2)	(2)	[1] 3 39
20	Thursday	(2)	5 15	.....	2 18	(2)	7 47
21	Friday	(2)	16 07	0 20	2 56	[1] 1 34	5 19
22	Saturday	(2)	10 51	.....	3 01	3 30	4 14
23	Sunday	(2)	12 13	.....	2 15	2 32	4 37
24	Monday	(2)	10 44	.....	2 34	3 15	5 48
25	Tuesday	(2)	8 21	.....	6 46	3 36	5 24
26	Wednesday	(2)	9 21	.....	3 39	2 52	[1] 2 14
27	Thursday	(2)	7 08	.....	4 53	4 06	(2)
28	Friday	(2)	11 07	.....	3 56	3 18	(2)
29	Saturday	(2)	16 07	1 52	4 40	3 18	(2)
30	Sunday	(2)	5 42	.....	3 52	3 34	(2)
Dec. 1	Monday	(2)	10 16	.....	3 16	6 07	(2)
2	Tuesday	(2)	8 12	.....	4 39	3 32	[1] 1 46
3	Wednesday	(2)	14 01	0 50	2 42	2 54	[1] 1 51
4	Thursday	[1] 2 33	7 22	.....	3 05	3 03	4 18
5	Friday	2 59	13 02	.....	3 56	3 00	6 23
6	Saturday	4 15	9 20	.....	4 43	2 48	[1] 6 41
7	Sunday	4 09	8 07	.....	3 35	3 11	[1] 0 41
8	Monday	5 38	9 01	.....	6 03	3 00	5 24
9	Tuesday	3 50	5 32	.....	3 17	2 53	6 59
10	Wednesday	4 27	7 17	.....	2 40	2 27	6 26
11	Thursday	2 43	9 06	.....	2 37	[1] 0 32	(2)
12	Friday	4 57	4 30	.....	[1] 1 12	(2)	(2)
13	Saturday	1 11	1 22	.....	.....	.....	.....
Total hours		36 42	220 04	3 02	82 35	65 02	79 31
Days of record		8.7	22.5	.....	22	19.7	13.5
Kw.-h./30-day month [3]		315	300	.....	225	250	440

[1] Less than a full 24-hour record on these days.
[2] No record on these days.
[3] Calculated from element size and total heating time.

TABLE III—Continued

TOTAL HEATING TIME FOR INDIVIDUAL WATER HEATERS—STEUBEN TEST

Date	Day	No. 61—43-gallon, single unit, 2.0	No. 65—52-gallon, single unit, 2.5	No. 66—80-gallon, single unit, 2.0	No. 67—82-gallon, single unit, 2.5	No. 73—50-gallon, single unit, 1.5
		Hr Min	Hr Min	Hr Min	Hr Min	Hr Min
Nov. 19	Wednesday	[1] 0 00	[1] 3 14	([2])	[1] 2 53	[1] 1 49
20	Thursday	1 31	4 33	([2])	5 18	3 58
21	Friday	6 24	3 14	([2])	5 23	3 35
22	Saturday	1 42	8 07	([2])	5 59	4 45
23	Sunday	2 39	5 35	([2])	6 50	4 19
24	Monday	1 25	7 10	([2])	6 46	7 16
25	Tuesday	1 16	4 12	([2])	[1] 3 24	3 18
26	Wednesday	1 03	3 21	[1] 1 04	[1] 3 43	3 40
27	Thursday	2 59	4 57	2 28	[1] 3 42	4 06
28	Friday	0 00	3 53	2 37	([2])	3 24
29	Saturday	2 28	5 30	3 09	([2])	4 28
30	Sunday	1 40	10 04	2 22	([2])	4 44
Dec. 1	Monday	1 28	12 25	2 40	([2])	3 51
2	Tuesday	1 49	7 56	4 53	[1] 2 31	7 55
3	Wednesday	[1] 1 19	3 38	2 46	5 23	3 59
4	Thursday	([2])	2 58	2 41	5 32	4 02
5	Friday	([2])	3 50	2 30	3 35	3 37
6	Saturday	([2])	7 17	2 47	5 08	8 43
7	Sunday	([2])	5 55	3 06	6 09	3 44
8	Monday	([2])	7 19	2 11	6 32	3 28
9	Tuesday	[1] 0 00	4 05	4 00	4 29	3 30
10	Wednesday	2 46	4 11	2 43	4 34	3 37
11	Thursday	1 15	4 34	2 37	5 17	3 41
12	Friday	[1] 1 36	[1] 1 35	[1] 1 07	[1] 4 02	[1] 1 14
Total hours		33 20	130 33	45 41	97 08	100 43
Days of record		17.1	22.7	15.7	17.4	22.7
Kw.-h./30-day month[3]		115	430	175	420	200

[1] Less than a full 24-hour record on these days.
[2] No record on these days.
[3] Calculated from element size and total heating time.

TABLE III—Continued

TOTAL HEATING TIME FOR INDIVIDUAL WATER HEATERS—STEUBEN TEST

Date	Day	No. 78–30 gallons		No. 80–65 gallon single unit, 3.0	No. 82–42 gallon single unit, 1.5	No. 97–43 gallon single unit, 2.0
		Lower, 1.5	Upper, 1.0			
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Nov. 19	Wednesday	(2)	.....	(2)	13 19	1 19
20	Thursday	[1] 3 22	.....	[1] 0 38	11 58	1 43
21	Friday	5 20	.....	9 32	10 54	1 55
22	Saturday	5 55	.....	4 43	12 30	[1] 1 02
23	Sunday	7 39	.....	8 09	8 14	(2)
24	Monday	6 35	.....	6 41	10 40	(2)
25	Tuesday	8 11	1 15	5 04	10 27	[1] 0 48
26	Wednesday	6 55	.....	5 35	13 22	(2)
27	Thursday	9 18	.....	5 38	10 24	(2)
28	Friday	10 18	.....	5 53	13 17	(2)
29	Saturday	12 03	.....	6 11	13 22	(2)
30	Sunday	8 19	.....	4 48	10 39	(2)
Dec. 1	Monday	8 21	.....	8 13	12 35	[1] 0 43
2	Tuesday	9 06	.....	5 42	10 53	2 00
3	Wednesday	12 38	.....	5 11	10 20	1 36
4	Thursday	5 55	.....	3 21	16 02	1 10
5	Friday	5 55	.....	8 21	10 20	1 44
6	Saturday	6 57	.....	6 42	10 33	1 40
7	Sunday	7 51	.....	6 52	8 47	1 37
8	Monday	10 42	.....	7 56	7 48	[1] 0 38
9	Tuesday	7 08	.....	5 27	12 21	2 39
10	Wednesday	7 16	.....	5 13	5 12	1 12
11	Thursday	4 51	.....	[1] 2 55	9 30	1 13
12	Friday	[1] 2 56	.....	(2)	12 03	[1] 0 35
Total hours		173 31	1 15	128 45	265 30	23 34
Days of record		22.1	.....	20.9	24	14.1
Kw.-h/30-day month [3]		350	.....	550	500	100

[1] Less than a full 24-hour record on these days.
[2] No record on these days.
[3] Calculated from element size and total heating time.

TABLE IV

CONSUMER INFORMATION AT SAMPLE HEATER LOCATIONS—STEUBEN TEST

Ref. No.	Number in household [1]		Farm business, type and scope	Total Kw.-h. Nov.[2]	Uses for hot water [3]		Water heater	
	A	Ch.			Bath	Farm uses	Gal.	Kw.
3	2	1	Dairy and diversified, 160 acres, 20 cows, 275 chickens, some hogs.	523 *120*	Shower	Wash milking machine and other utensils, warm drinking water for calves, poultry, hogs.	43	[4] 0.75 [5] 1.5 Units not interconnected. Installed before 1944.
6	2	2	Crop and livestock, 80 acres, no dairying.	633 *375*	Shower and tub.	None	82	2.75 Installed October 1947.
16	2	0	None. Stable some trotting horses for neighbor.	517 *155*	Tub	None	52	2.0
26	2	0	Crop and livestock, 3 dairy cows, 80 acres.	565 *350*	Tub	Wash milking utensils and cows' udders twice daily.	52	1.5 Installed in 1946.
30	3	2	Dairy and diversified, 120 acres, milking 15 cows at time of test.	574 *315*	Tub	Rinse and wash milking machine, warm water for calves to drink.	52	2.5 Installed before 1944.
32	3	0	Dairy and diversified, 160 acres, milking 13 cows at time of test.	740 *300*	Tub	Wash milking machine and other utensils in house.	52	[4] 1.0 [5] 2.0
48	2	0	Dairy and diversified, 80 acres. Milking 5 cows at time of record.	496 *225*	Shower	Wash milking machine and other utensils in house.	66	2.0 Installed in 1942.
51	4	0	Crop and livestock, mostly beef cattle, 120 acres.	319 *250*	Tub	None	80	2.5 Installed June 1947.
56	2	0	Crop and livestock, 300 acres, with 3 other houses on farm. Milk 1 cow.	554 *440*	Tub	None	50	2.5 Installed October 1947.
61	2	0	Crop farm. About 5 cows being milked.	412 *115*	Tub	Milk utensils washed in house.	43	2.0 Installed in 1946.
65	2	2	Dairy and diversified. 300 acres. Milking 6 cows at time of record.	656 *430*	Tub	Wash milking machine and other utensils in house.	52	2.5
66	2	0	Dairy and diversified, 60 acres. Milking 3 cows at time of record.	390 *175*	Shower	Wash milk utensils in house.	80	2.0 Installed May 1946.
67	3	3	Dairy and diversified. Milking 10 cows at time of record.	732 *420*	Tub	Carried to barn for milking machine and utensils.	82	2.5 Installed September 1947.
73	3	0	Crop and livestock 50 acres, milk 1 or 2 cows.	338 *200*	Tub	None used outside house.	50	1.5 Installed in 1945.

See footnotes at end of table.

TABLE IV—Continued

CONSUMER INFORMATION AT SAMPLE HEATER LOCATIONS—STEUBEN TEST—Con.

Ref. No.	Number in household [1]		Farm business, type and scope	Total Kw.-h. Nov.[2]	Uses for hot water [3]		Water heater	
	A	Ch.			Bath	Farm uses	Gal.	Kw.
78	2	1	Dairy and diversified, 100 acres. Milking 6 cows at time of record.	697 *350*	Shower	Wash milking utensils and cows, udders. Warm water for chickens and hogs.	30	[4] 1.5 [5] 1.0 Installed August 1947
80	3	0	Dairy and diversified, 120 acres. Milking 4 cows at time or record.	707 *550*	Shower	Wash milking machine and cream separator in house.	65	3.0 Installed November 1945.
82	2	2	Dairy and diversified, 120 acres. Milking 10 cows at time of record.	519 *500*	Tub	Wash milking machine and other utensils in house.	42	1.5 Installed 1945.
97	2	0	Dairy and diversified, 60 acres. Milking 4 cows at time of record.	208 *100*	Tub	Wash cream separator and milk utensils in house.	43	2.0 Installed 1943.

[1] Persons more than 12 years of age are shown as adults (A.); those less than 12 as children (Ch.).
[2] First figure is energy billed for all uses in Nov. 1947. Italic figure is Kw.-h. per month for water heating from table III.
[3] All users had washing machines for laundry. Only one (Ref. No. 32) had automatic type machine.
[4] Lower element.
[5] Upper element.

REMARKS FROM TABLE IV.

Ref. No.

3 Upper thermostat cut on at lower temperature than the lower one, though both thermostats were set at 150. Range boiler with furnace coil was connected ahead of electric water heater. Water from range boiler often was hot enough so that lower element never came on at all. Hot water supply is not adequate when furnace is off.

6 Children ages 3 and 5. Thermostat set at 140. Hot water supply is adequate.

16 Farm buildings are used only as residence. Recording meter was removed December 3 after this couple left to be gone several weeks. Thermostat at 155.

26 One additional adult present part of the time; one child, age 12, was present during first week of record. Thermostat at 149.

30 Dairy uses about 5 gallons twice daily drawn from the hot tap. Water used for milking machine, then for calves. Thermostat at 153.

32 Water heater was installed before young couple moved in a year ago. Bendix automatic washer. Thermostats at 150, not interconnected.

48 Thermostat at 150.

51 Thermostat on "Medium."

56 Thermostat at 150.

61 Thermostat at 150.

65 Thermostat at 150.

66 Thermostat at 158.

67 Thermostat at 150.

73 One bedridden invalid in house. Thermostat at 170.

78 Upper unit may have been disconnected during last part of test because owner thought it should not be used. Thermostat at 150.

80 Loss of heat through the insulation of heater was excessive. Insulation had settled down so that only an air space separated tank and outer jacket, along the upper third of the tank. Thermostat at 150.

82 Owner used a water heater in previous residence 3 years before 1945. Children ages 1 and 3 years. Thermostat at 150.

97 Thermostat at 150.

TABLE V

CONSUMER INFORMATION AT SAMPLE HEATER LOCATIONS—STEUBEN TEST

REF. NO.	Kilowatt-hours Billed Monthly During 1947										
	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.
3	380	396	364	443	500	483	494	506	392	428	523
6	241	214	133	254	192	378	556	512	625	291	633
16	.....	.....	.....	.....	369	378	405	477	450	501	517
26	284	190	278	425	559	485	522	538	539	508	565
30	825	460	814	590	731	448	507	479	581	640	574
32	685	454	492	537	433	455	365	454	748	695	740
48	390	445	387	394	313	326	307	351	192	353	496
51	86	88	95	215	237	265	274	287	292	274	319
56	211	369	88	90	99	548	395	281	507	698	554
61	260	286	338	313	286	302	320	338	315	330	412
65	627	548	917	910	543	952	528	530	639	332	656
66	219	176	147	271	112	199	304	293	326	331	390
67	198	282	219	295	725	349	388	514	537	587	732
73	108	92	89	78	106	191	276	264	260	262	338
78	637	693	613	901	394	590	2	394	486	573	697
80	857	970	799	777	709	774	616	642	824	776	707
82	536	491	563	271	532	421	405	415	450	434	519
97	234	208	582	259	184	177	222	193	201	159	208

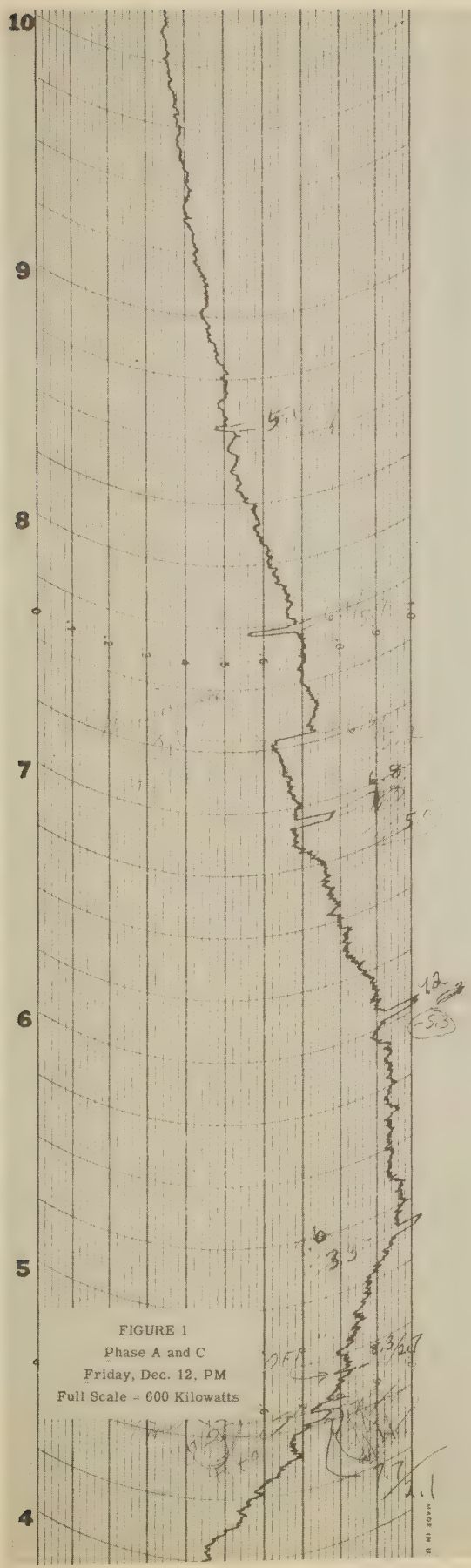


FIGURE 1
Phase A and C
Friday, Dec. 12, PM
Full Scale = 600 Kilowatts

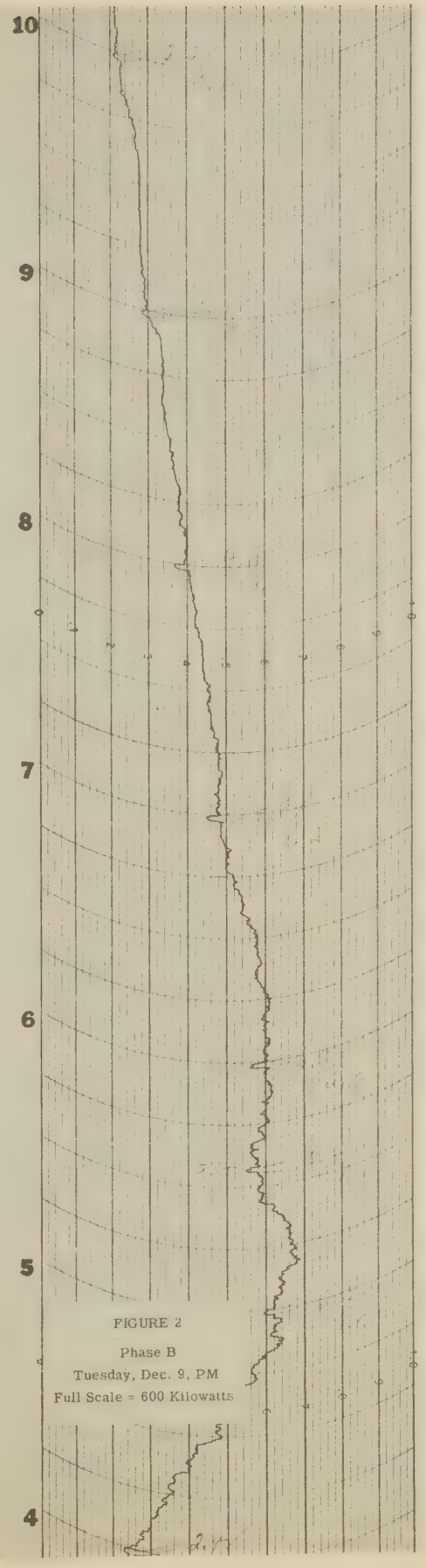


FIGURE 2
Phase B
Tuesday, Dec. 9, PM
Full Scale = 600 Kilowatts

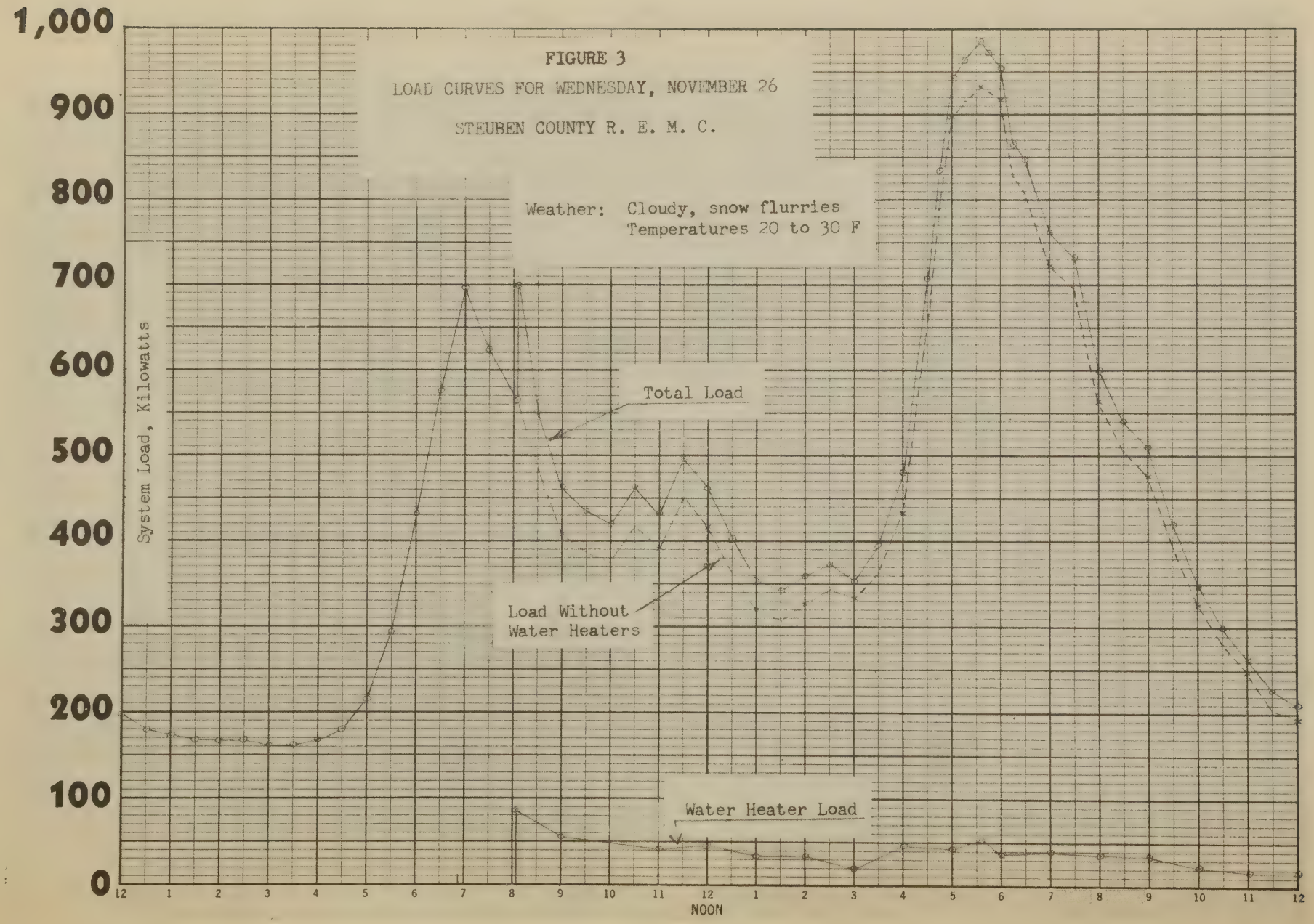


FIGURE 3
LOAD CURVES FOR WEDNESDAY, NOVEMBER 26
STEUBEN COUNTY R. E. M. C.
Weather: Cloudy, snow flurries
Temperatures 20 to 30 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without
Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 4

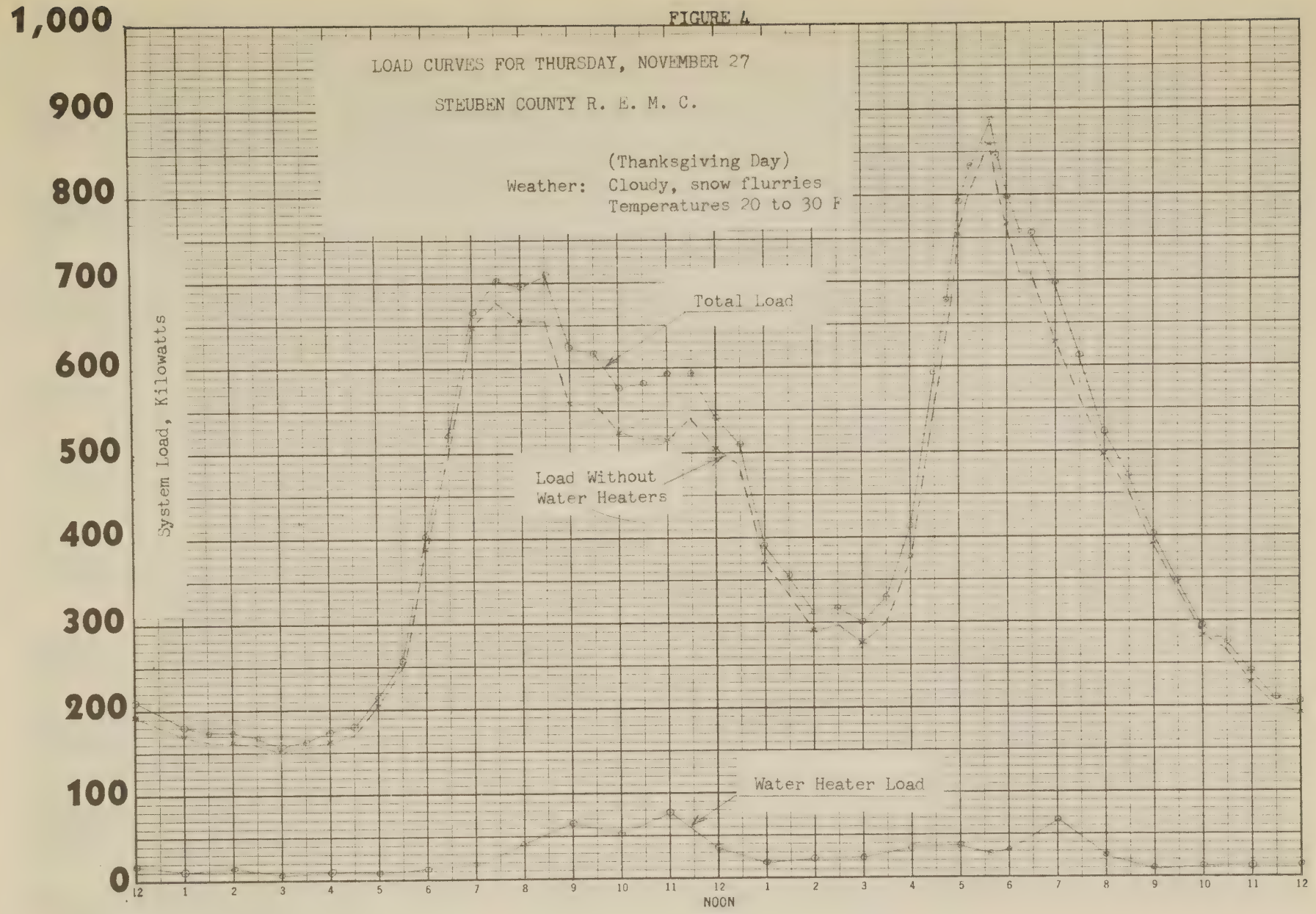

LOAD CURVES FOR THURSDAY, NOVEMBER 27
STEUBEN COUNTY R. E. M. C.
(Thanksgiving Day)
Weather: Cloudy, snow flurries
Temperatures 20 to 30 F
Total Load
Load Without Water Heaters
Water Heater Load
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 5

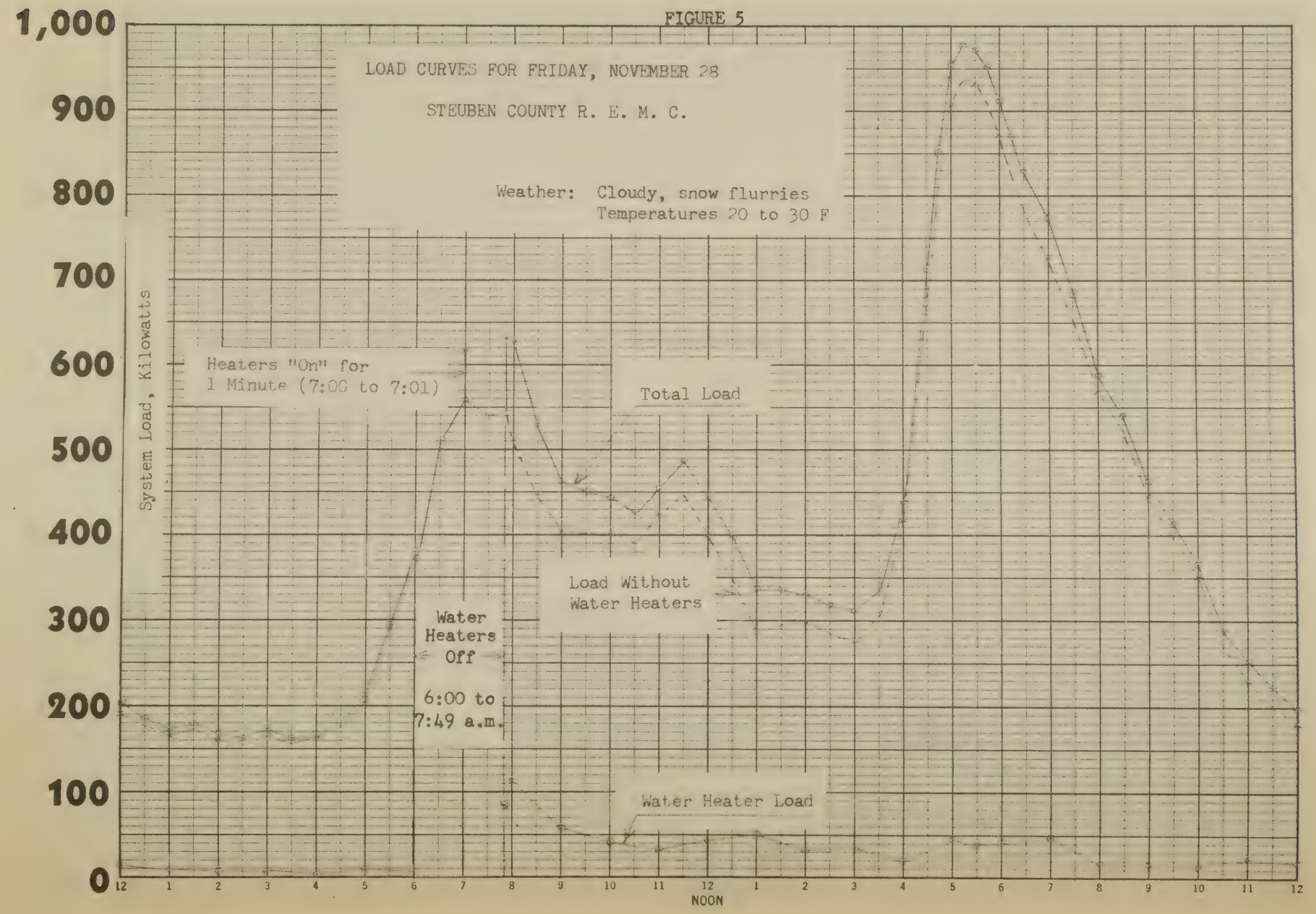

LOAD CURVES FOR FRIDAY, NOVEMBER 28
STEUBEN COUNTY R. E. M. C.
Weather: Cloudy, snow flurries
Temperatures 20 to 30 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Heaters "On" for
1 Minute (7:00 to 7:01)
Total Load
Load Without
Water Heaters
Water
Heaters
Off
6:00 to
7:49 a.m.
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 6

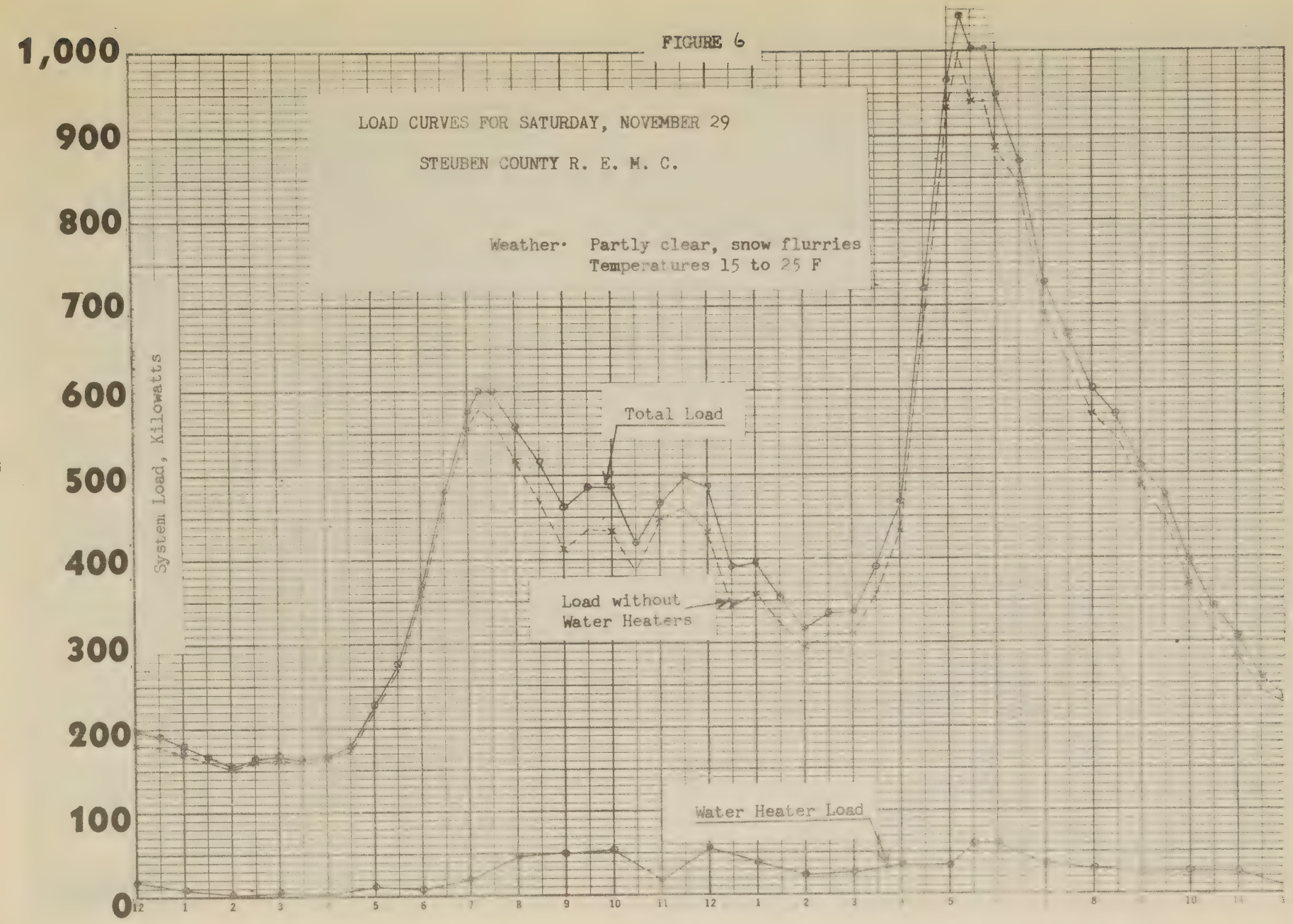

LOAD CURVES FOR SATURDAY, NOVEMBER 29
STEUBEN COUNTY R. E. M. C.
Weather· Partly clear, snow flurries
Temperatures 15 to 25 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load without
Water Heaters
Water Heater Load
12
1
2
3
5
6
7
8
9
10
11
12
1
2
3
5
8
10

FIGURE 7

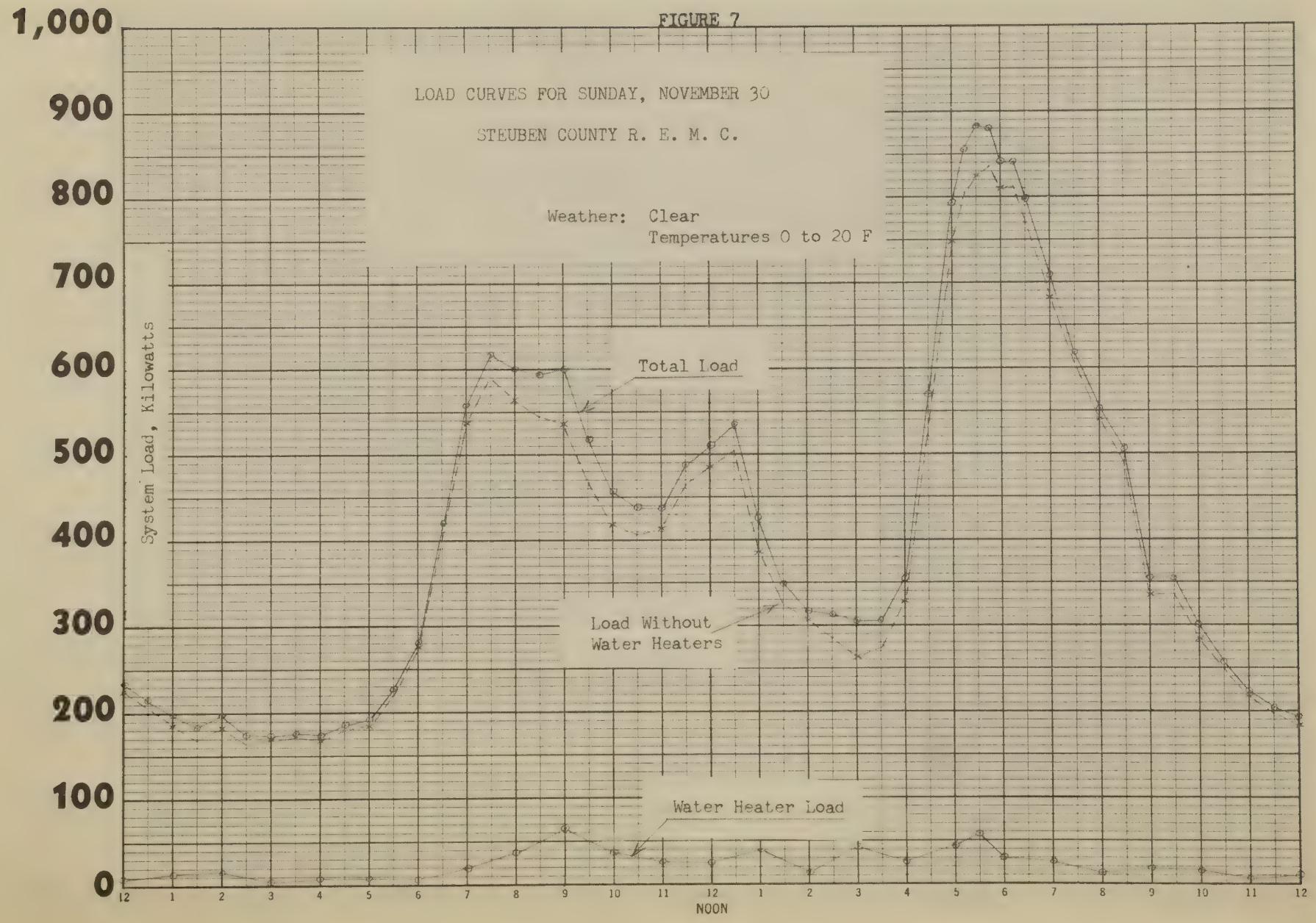

LOAD CURVES FOR SUNDAY, NOVEMBER 30
STEUBEN COUNTY R. E. M. C.
Weather: Clear
Temperatures 0 to 20 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without
Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 8

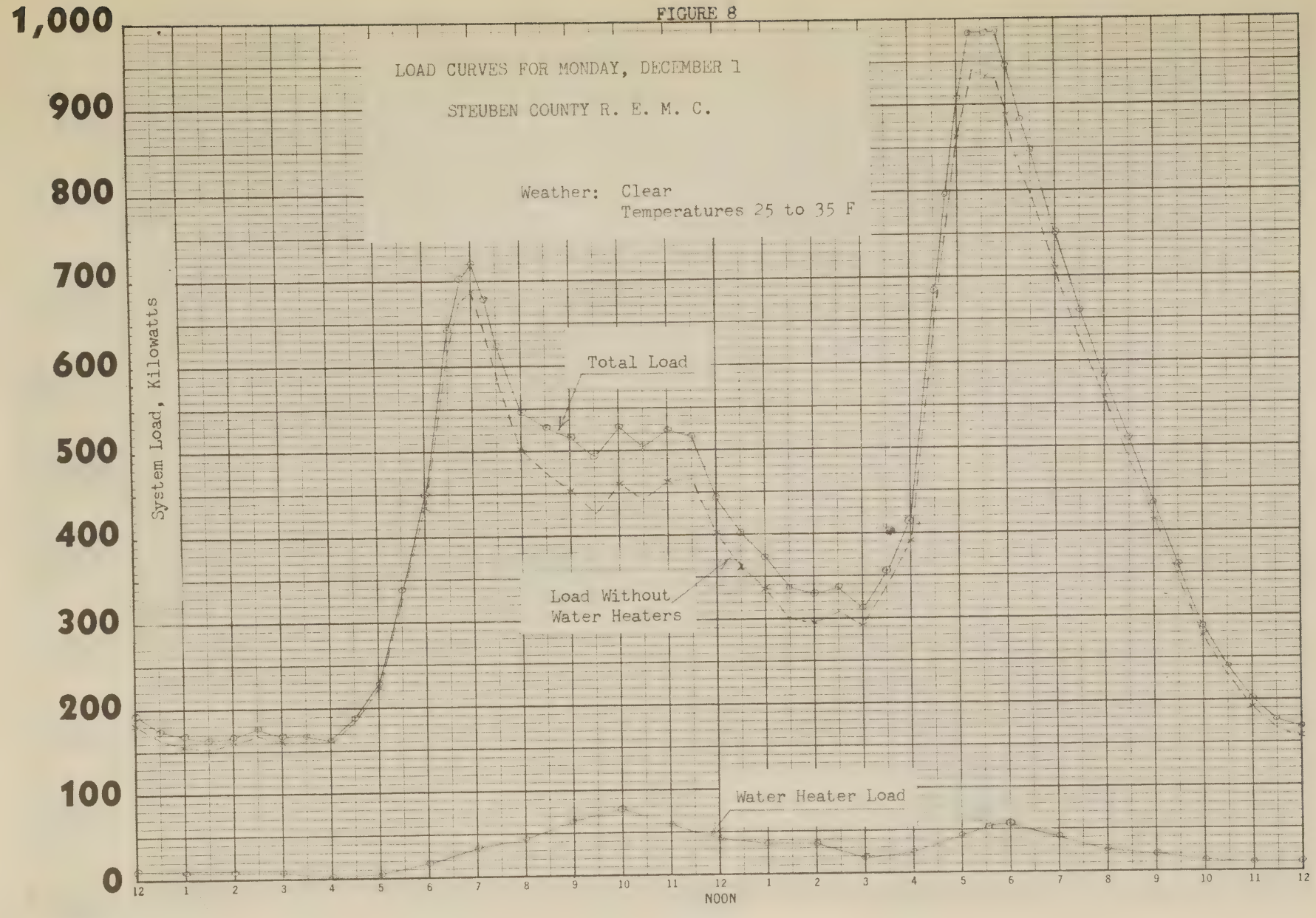

LOAD CURVES FOR MONDAY, DECEMBER 1
STEUBEN COUNTY R. E. M. C.
Weather: Clear
Temperatures 25 to 35 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 9

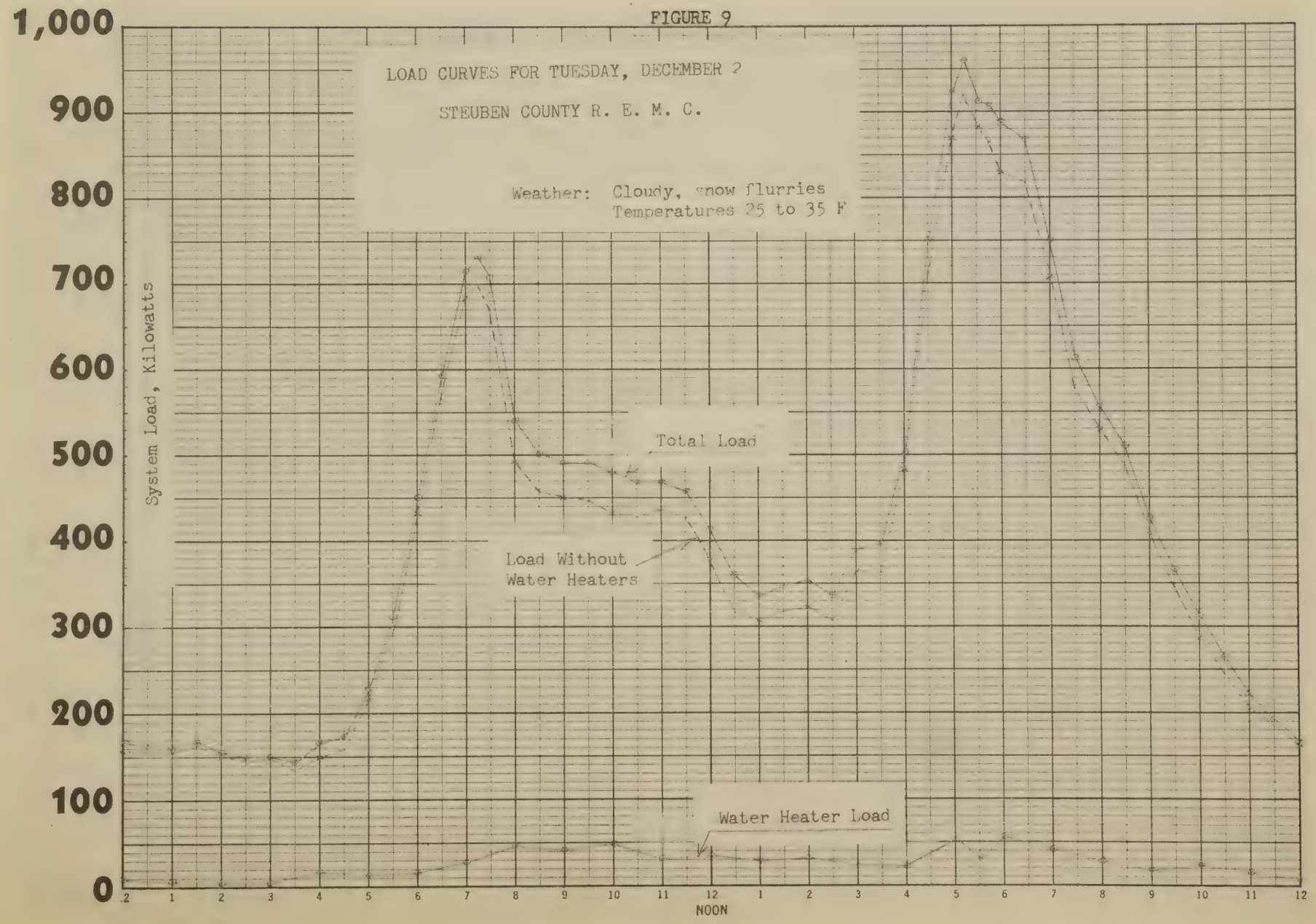

LOAD CURVES FOR TUESDAY, DECEMBER 2
STEUBEN COUNTY R. E. M. C.
Weather: Cloudy, snow flurries
Temperatures 25 to 35 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without
Water Heaters
Water Heater Load
12
1
2
3
4
5
6
7
8
9
10
11
12
NOON
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE 10

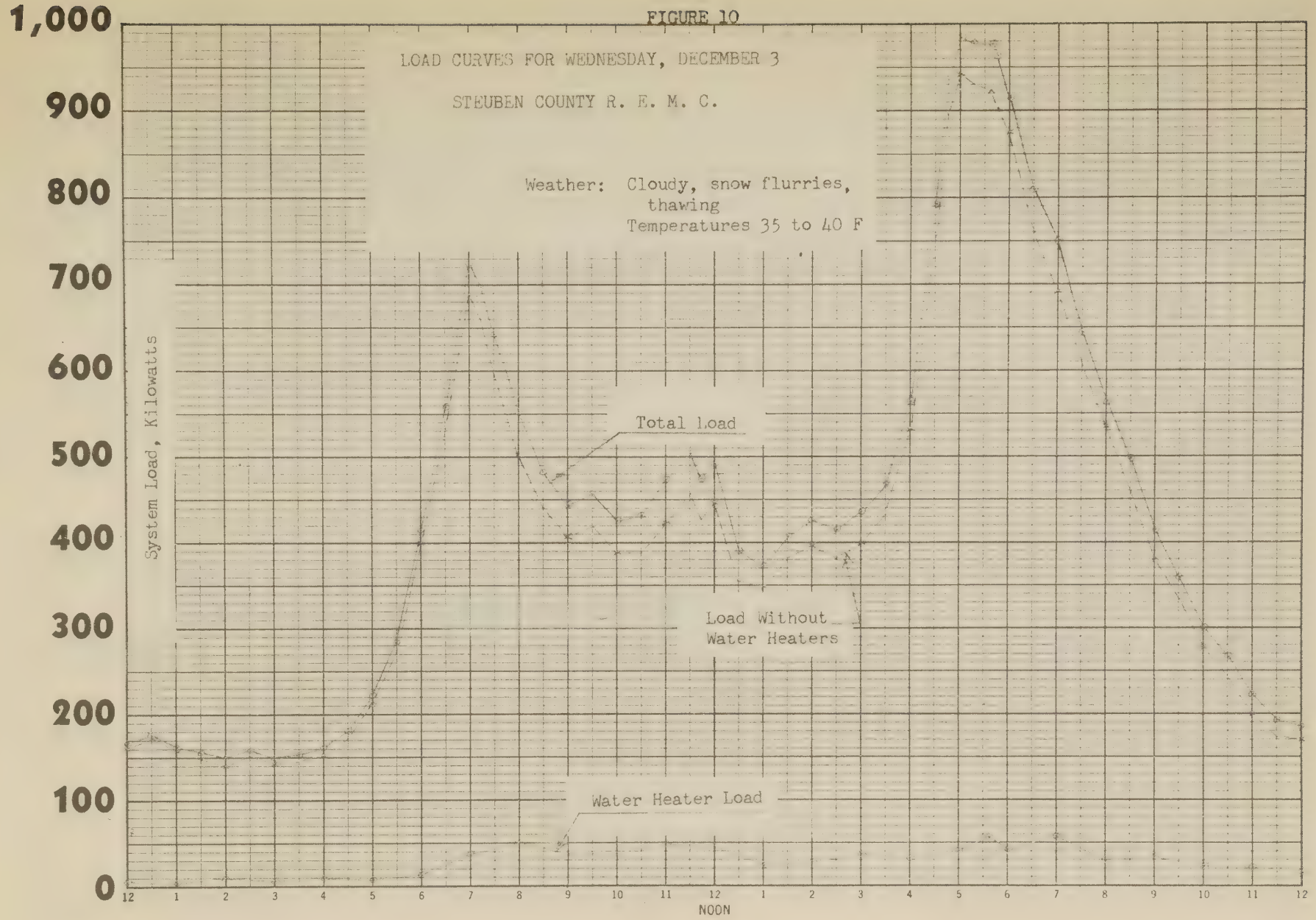

LOAD CURVES FOR WEDNESDAY, DECEMBER 3
STEUBEN COUNTY R. E. M. C.
Weather: Cloudy, snow flurries, thawing
Temperatures 35 to 40 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 11

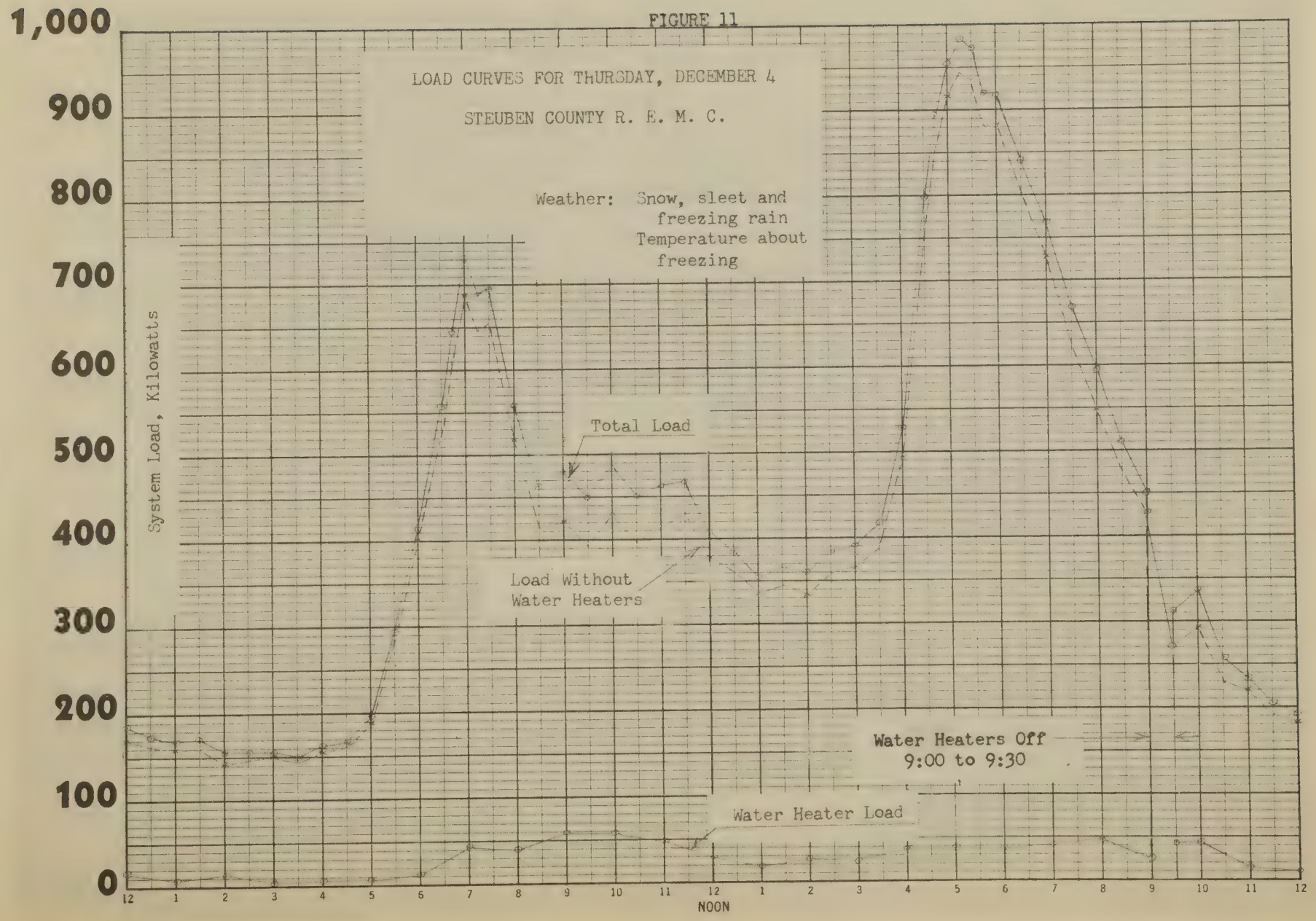

LOAD CURVES FOR THURSDAY, DECEMBER 4
STEUBEN COUNTY R. E. M. C.
Weather: Snow, sleet and freezing rain
Temperature about freezing
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without Water Heaters
Water Heaters Off 9:00 to 9:30
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 12

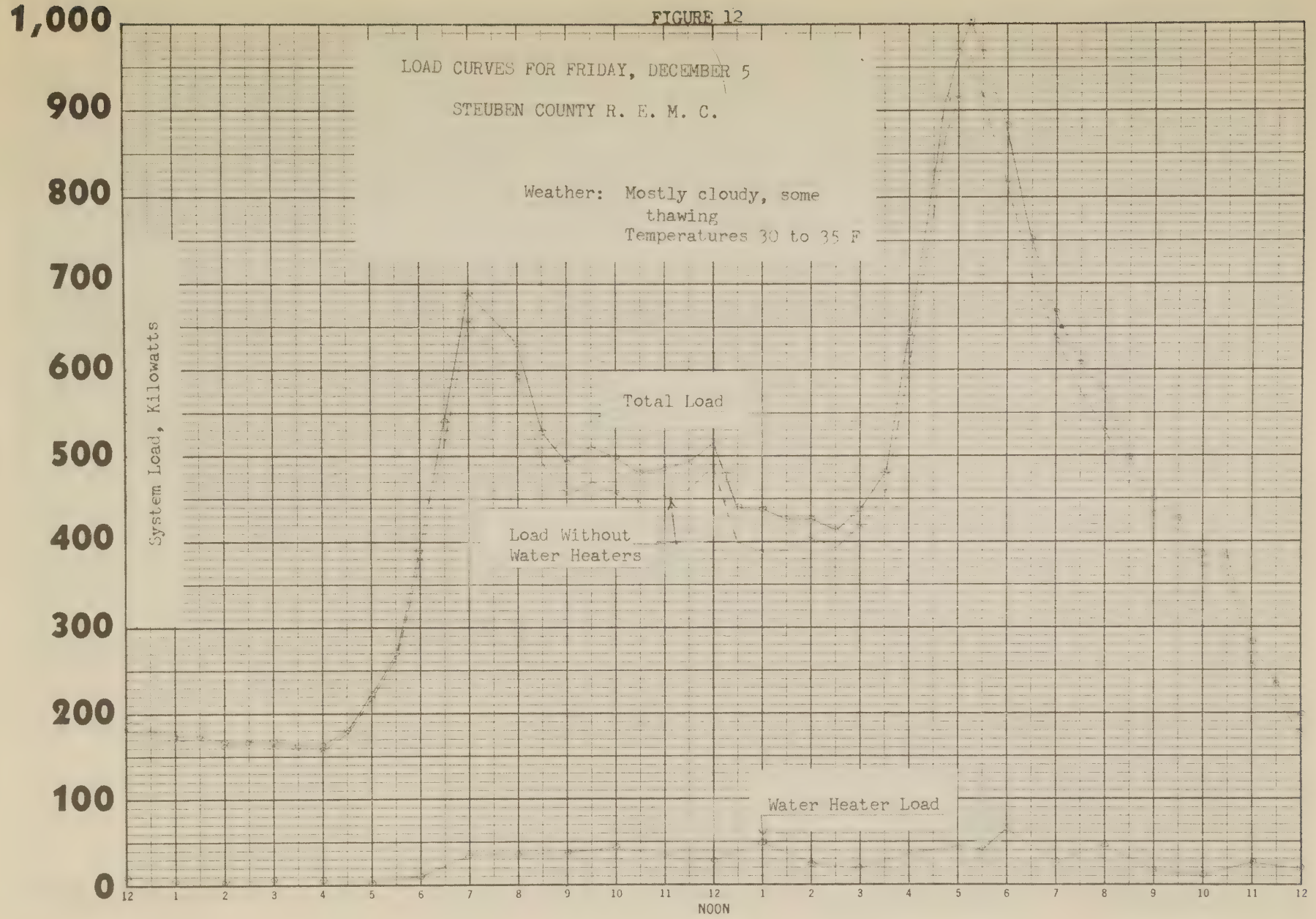

LOAD CURVES FOR FRIDAY, DECEMBER 5
STEUBEN COUNTY R. E. M. C.
Weather: Mostly cloudy, some thawing
Temperatures 30 to 35 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 13

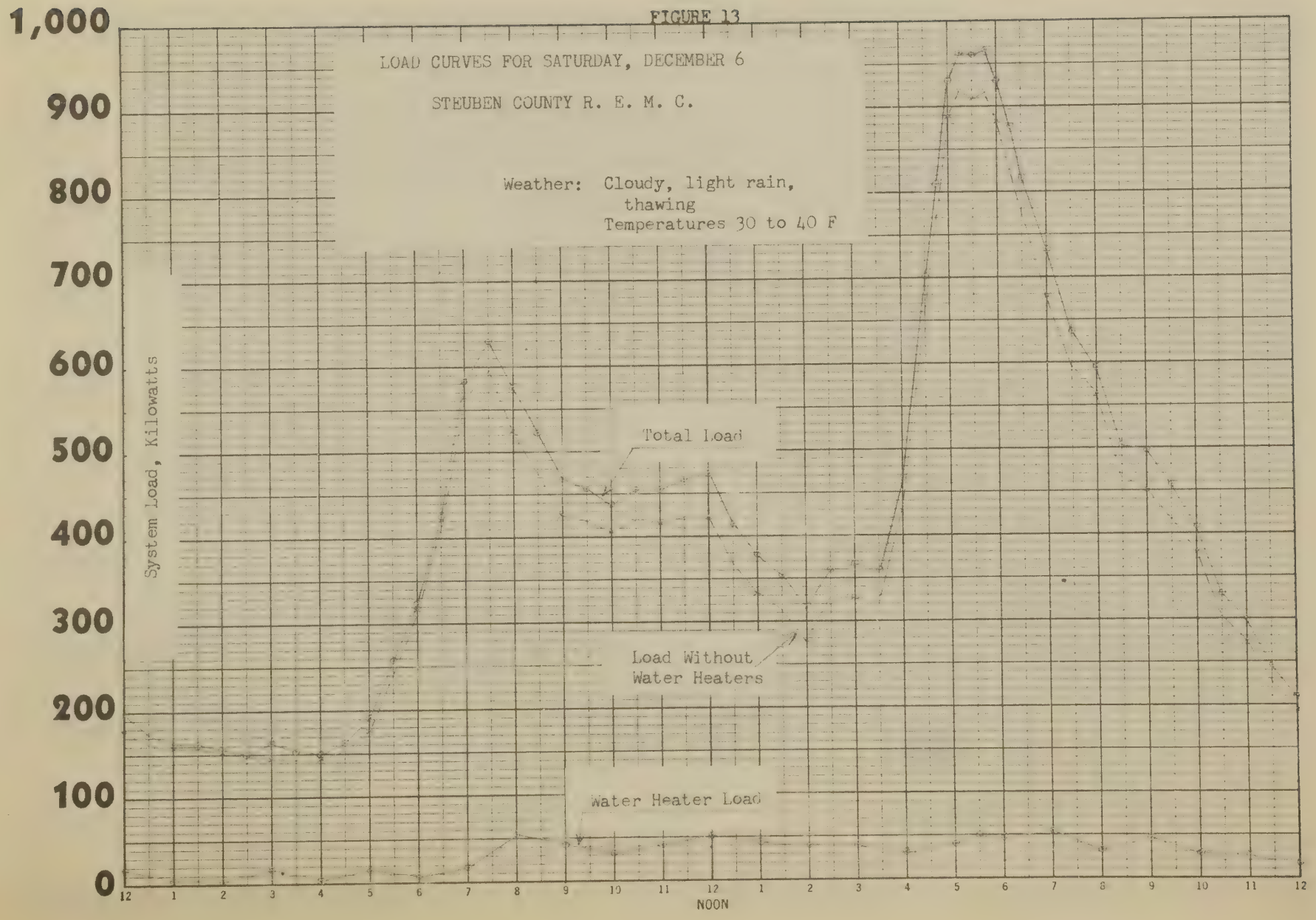

LOAD CURVES FOR SATURDAY, DECEMBER 6
STEUBEN COUNTY R. E. M. C.
Weather: Cloudy, light rain, thawing
Temperatures 30 to 40 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 14

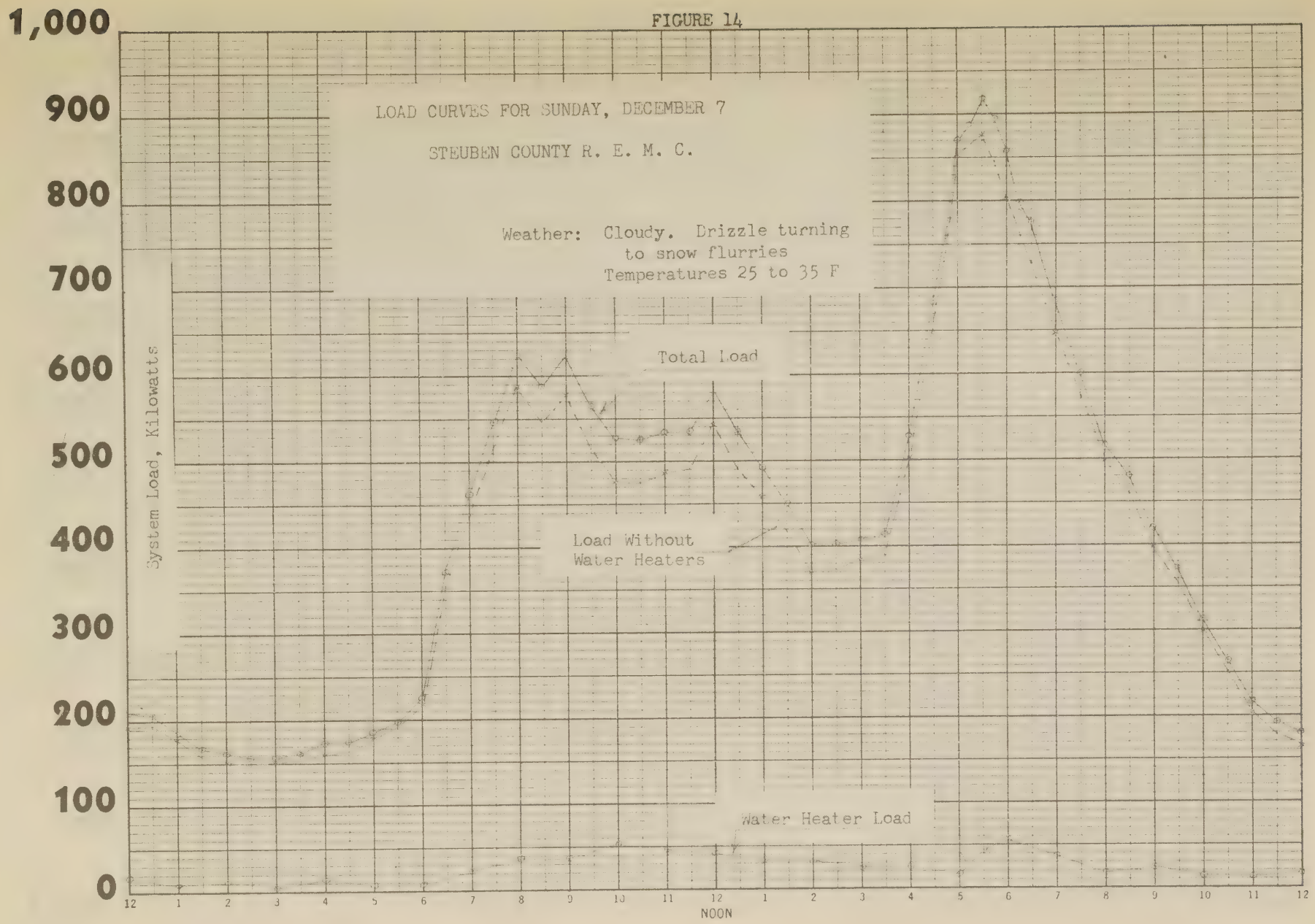

LOAD CURVES FOR SUNDAY, DECEMBER 7
STEUBEN COUNTY R. E. M. C.
Weather: Cloudy. Drizzle turning to snow flurries
Temperatures 25 to 35 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 15

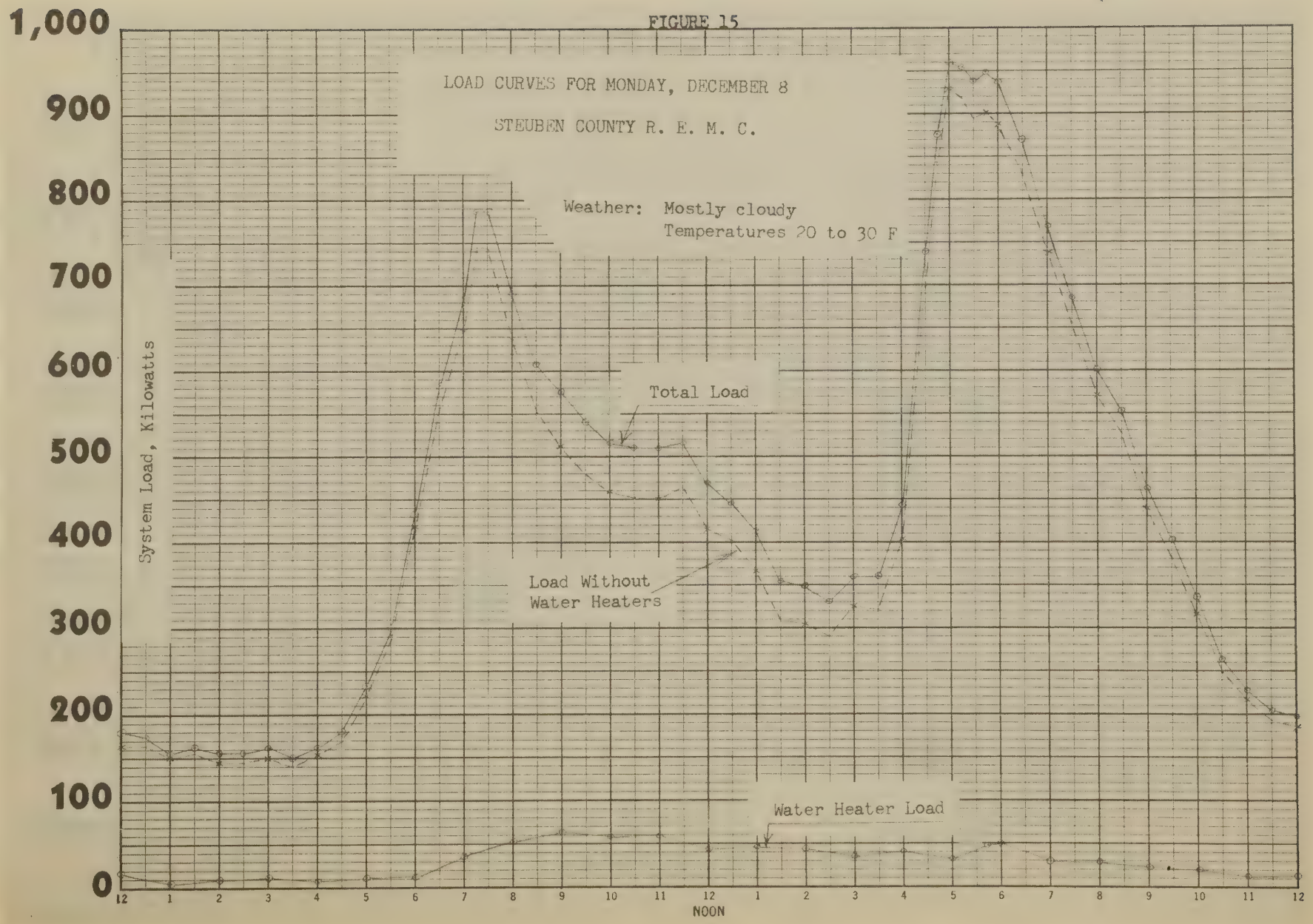

LOAD CURVES FOR MONDAY, DECEMBER 8
STEUBEN COUNTY R. E. M. C.
Weather: Mostly cloudy
Temperatures 20 to 30 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without
Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 16

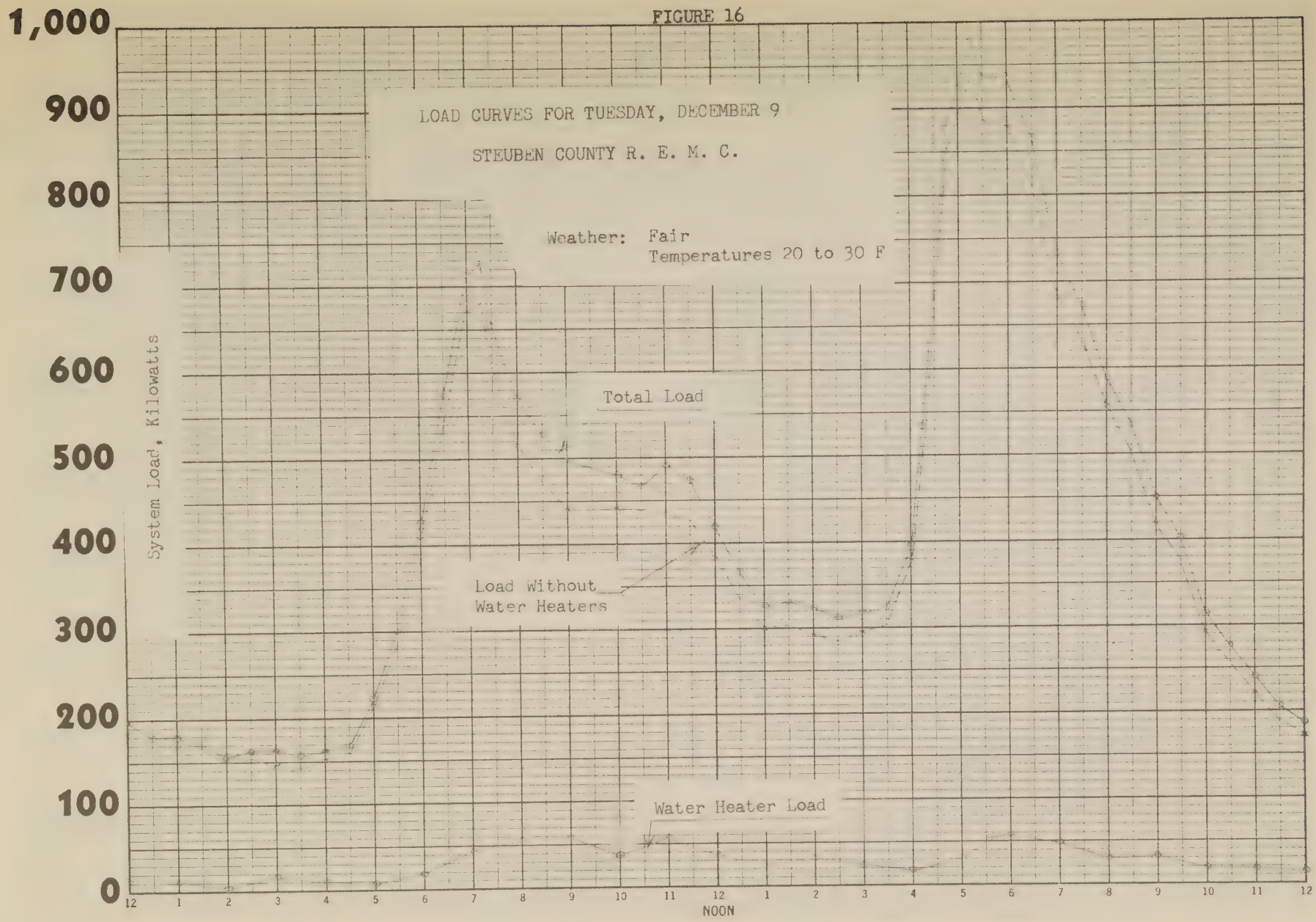

LOAD CURVES FOR TUESDAY, DECEMBER 9
STEUBEN COUNTY R. E. M. C.
Weather: Fair
Temperatures 20 to 30 F
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without
Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 17

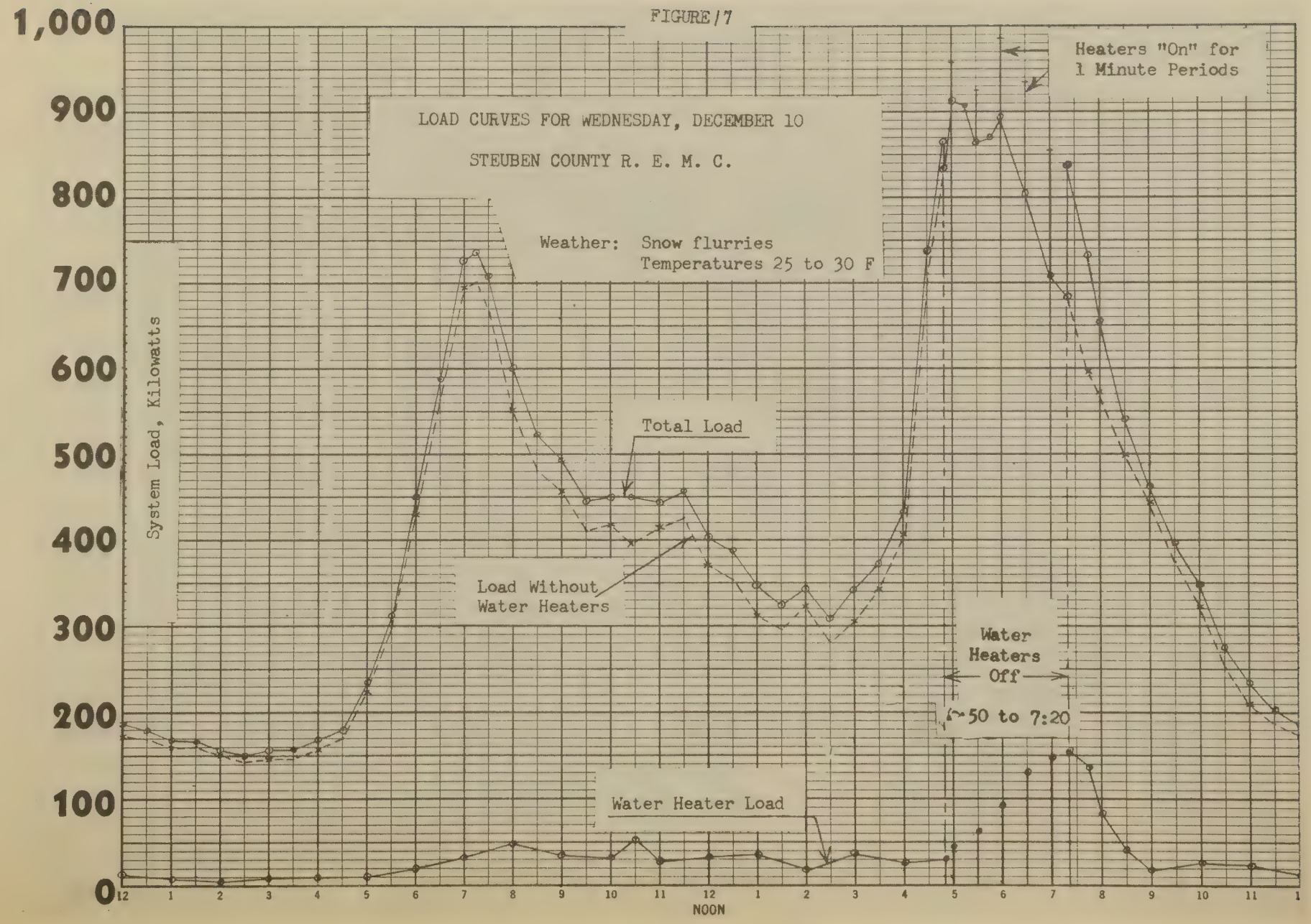

LOAD CURVES FOR WEDNESDAY, DECEMBER 10
STEUBEN COUNTY R. E. M. C.
Weather: Snow flurries
Temperatures 25 to 30 F
Heaters "On" for
1 Minute Periods
System Load, Kilowatts
Total Load
Load Without
Water Heaters
Water
Heaters
Off
~50 to 7:20
Water Heater Load
1,000
900
800
700
600
500
400
300
200
100
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 1
NOON

FIGURE 18

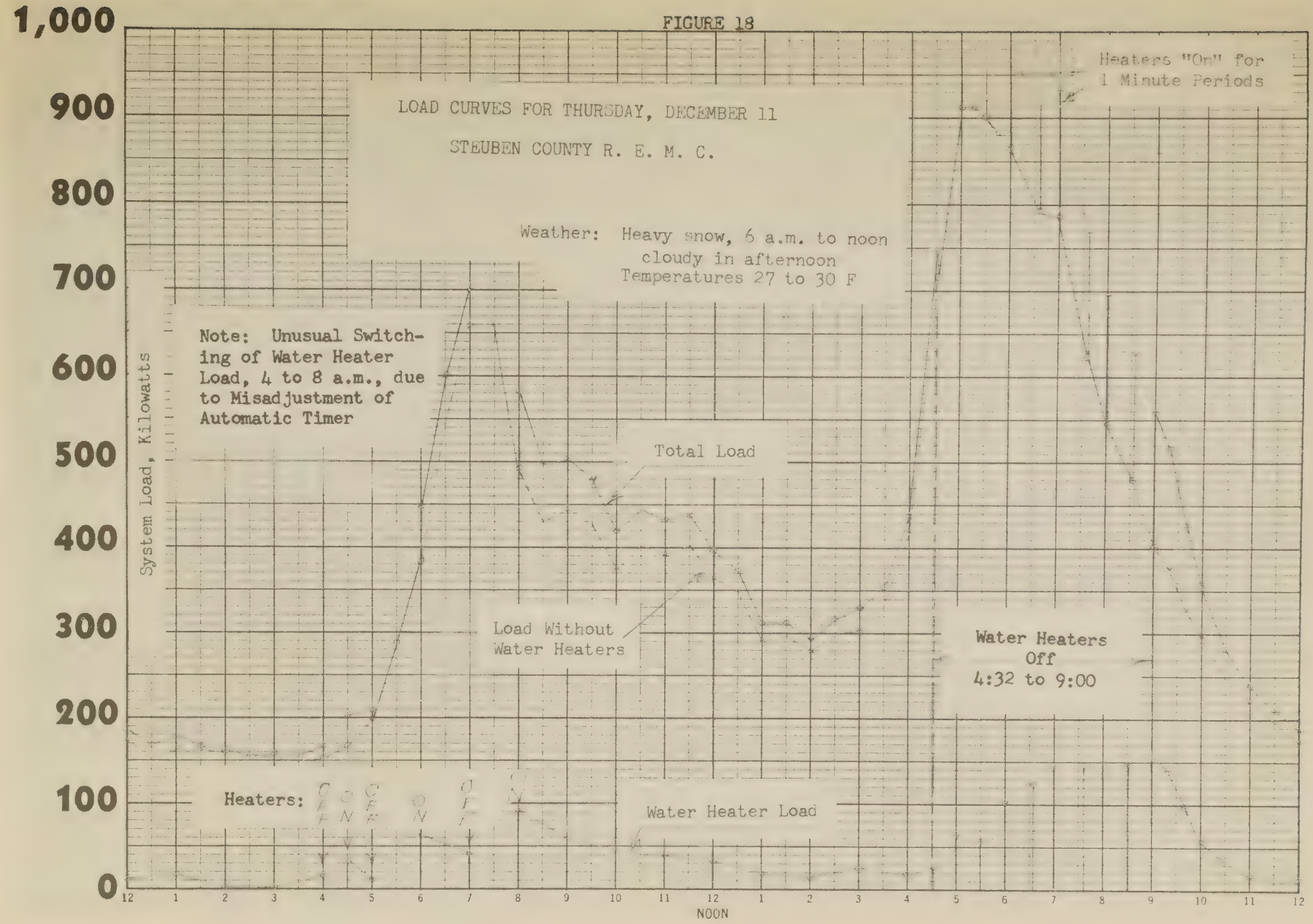

LOAD CURVES FOR THURSDAY, DECEMBER 11
STEUBEN COUNTY R. E. M. C.
Weather: Heavy snow, 6 a.m. to noon
cloudy in afternoon
Temperatures 27 to 30 F
Heaters "On" for
1 Minute Periods
Note: Unusual Switching of Water Heater Load, 4 to 8 a.m., due to Misadjustment of Automatic Timer
Total Load
Load Without Water Heaters
Water Heaters Off 4:32 to 9:00
Heaters:
Water Heater Load
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 19

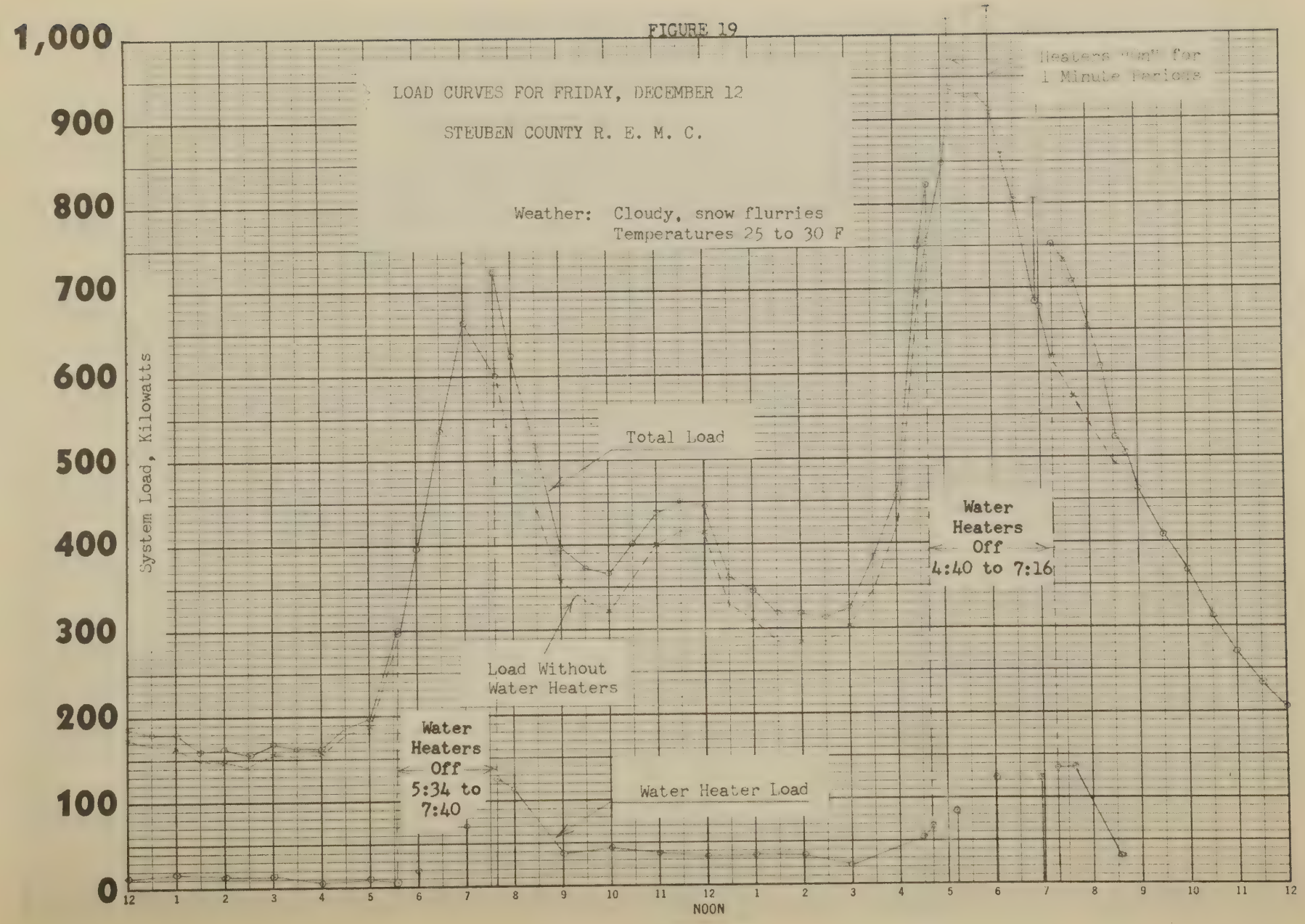
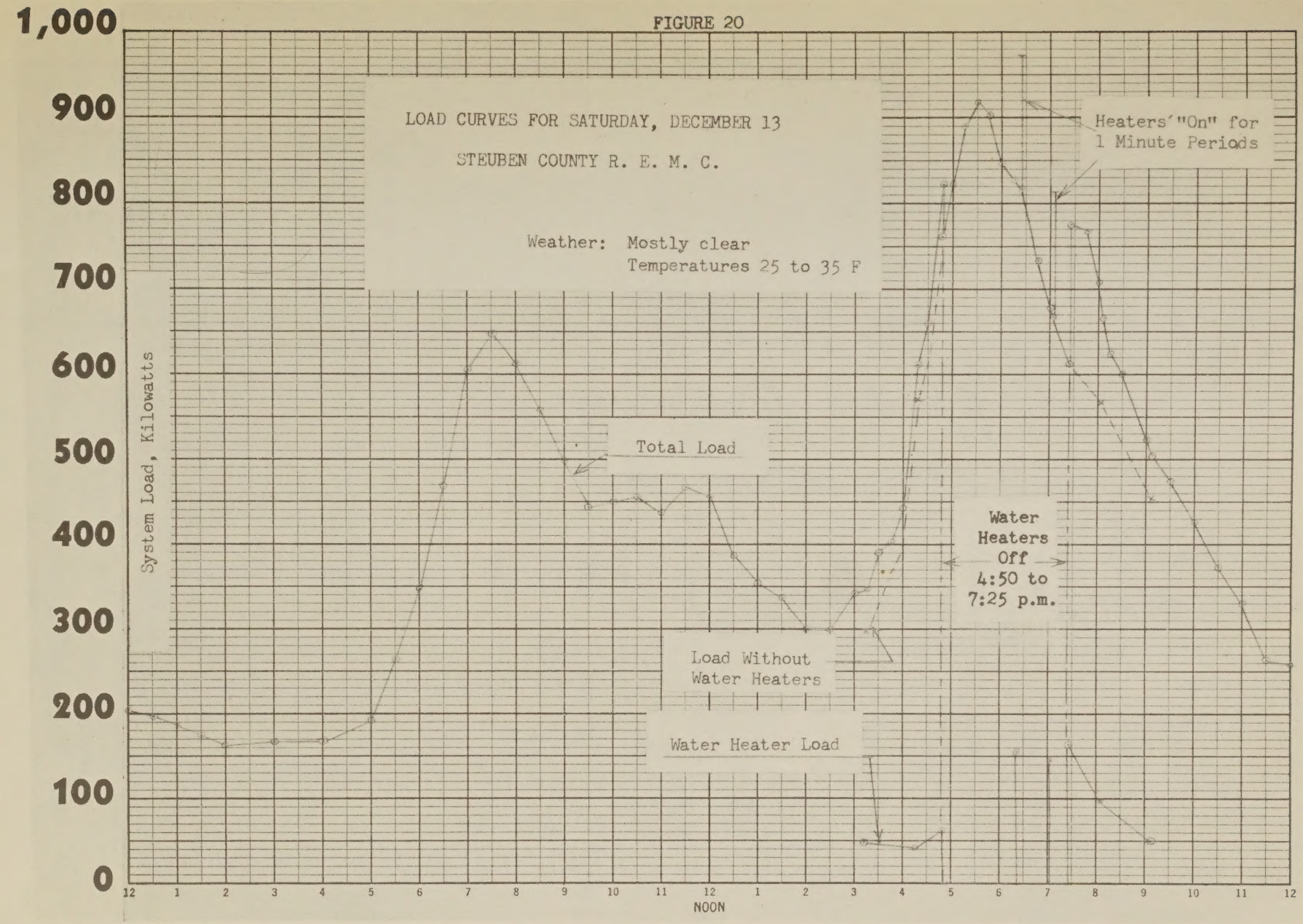

LOAD CURVES FOR FRIDAY, DECEMBER 12
STEUBEN COUNTY R. E. M. C.
Weather: Cloudy, snow flurries
Temperatures 25 to 30 F
Heaters "On" for 1 Minute Periods
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Load Without Water Heaters
Water Heater Load
Water Heaters Off 5:34 to 7:40
Water Heaters Off 4:40 to 7:16
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

FIGURE 20


LOAD CURVES FOR SATURDAY, DECEMBER 13
STEUBEN COUNTY R. E. M. C.
Weather: Mostly clear
Temperatures 25 to 35 F
Heaters "On" for 1 Minute Periods
System Load, Kilowatts
1,000
900
800
700
600
500
400
300
200
100
0
Total Load
Water Heaters Off 4:50 to 7:25 p.m.
Load Without Water Heaters
Water Heater Load
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON

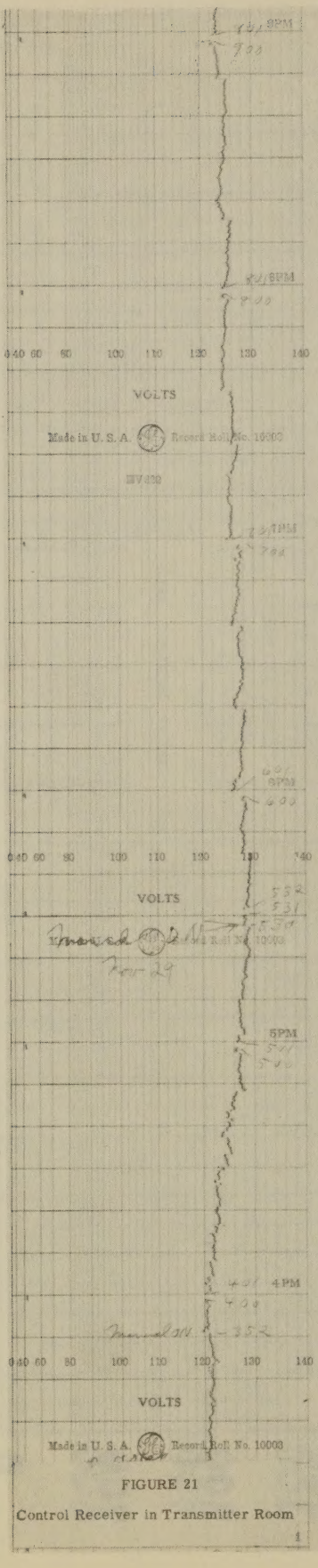


FIGURE 21

Control Receiver in Transmitter Room

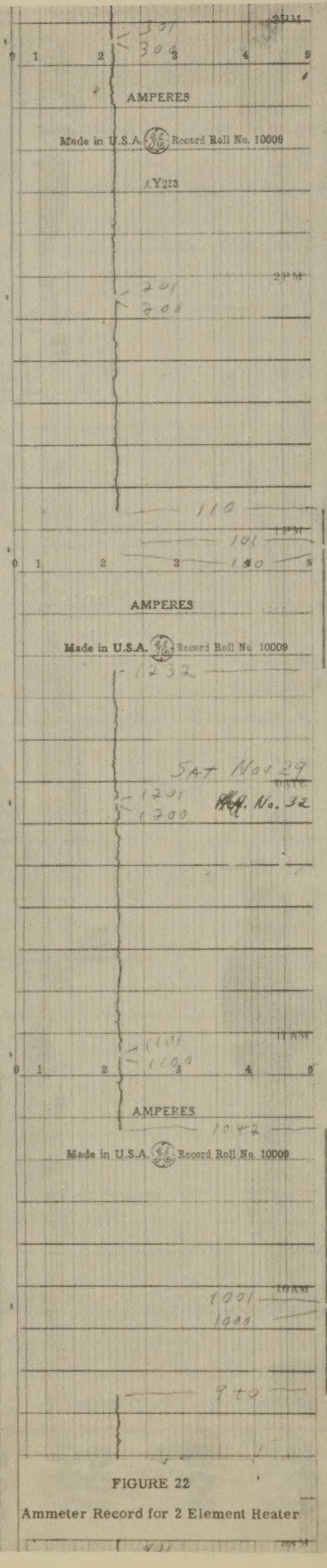


FIGURE 22

Ammeter Record for 2 Element Heater

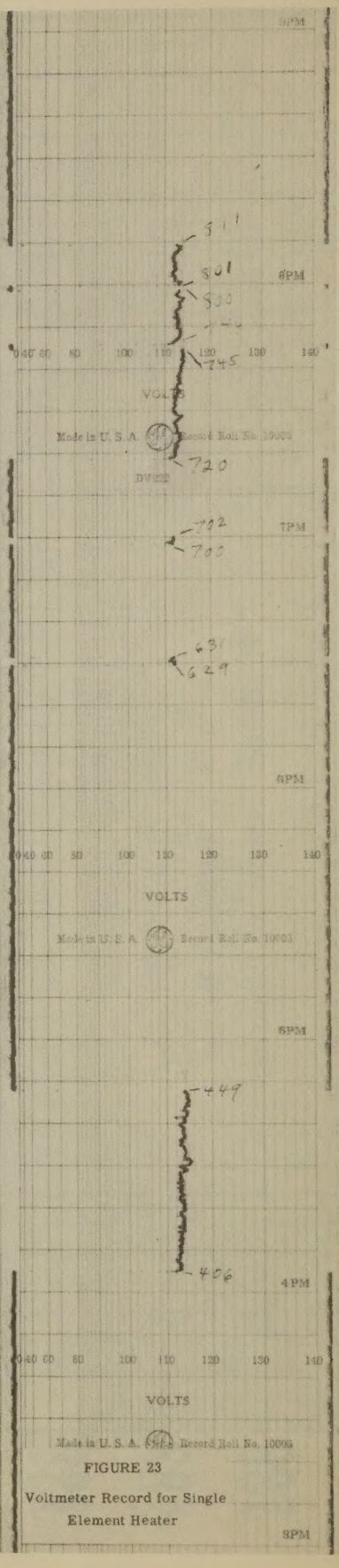


FIGURE 23

Voltmeter Record for Single Element Heater

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